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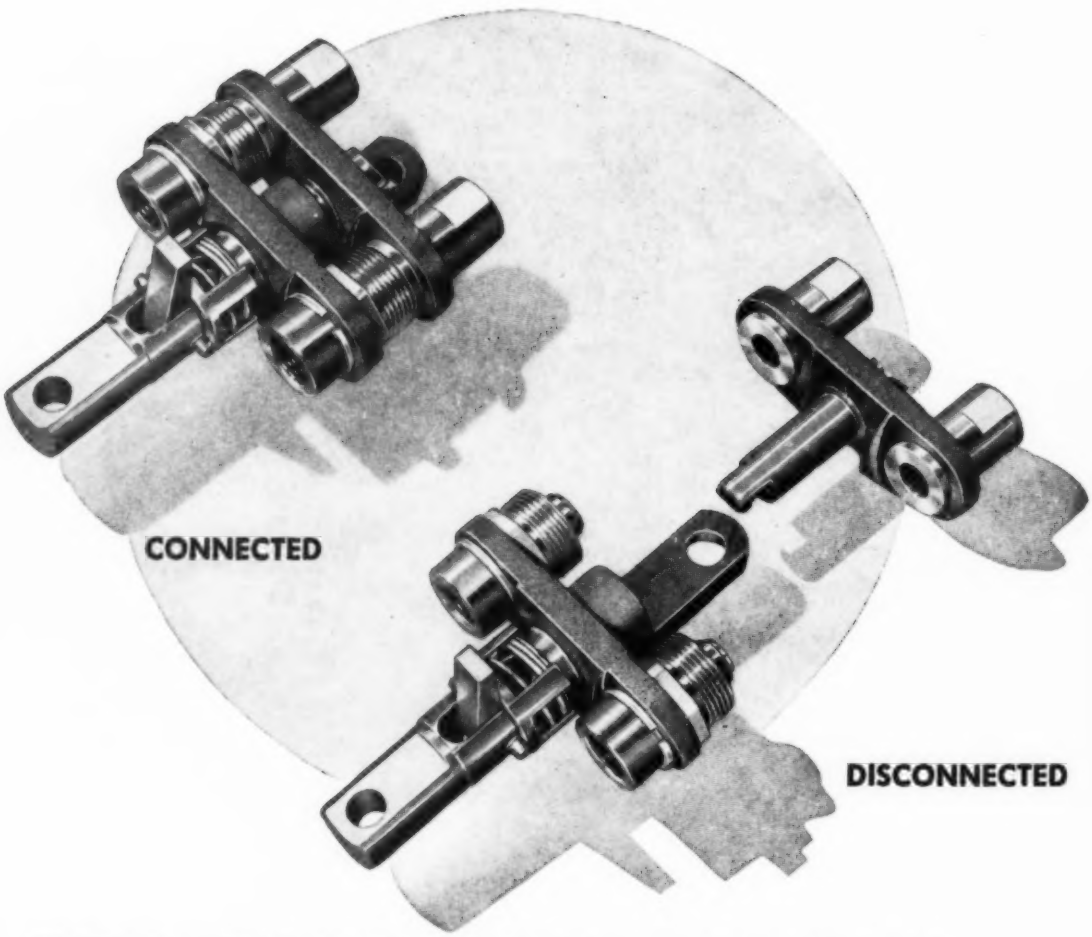

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FRONT PAGE: A production line of clamping and riveting machines assembling commutators in the shop of Han-Kor Incorporated. For story see page 10.

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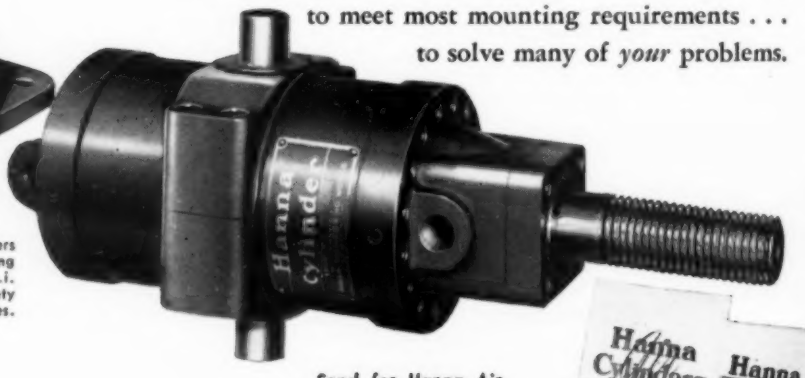

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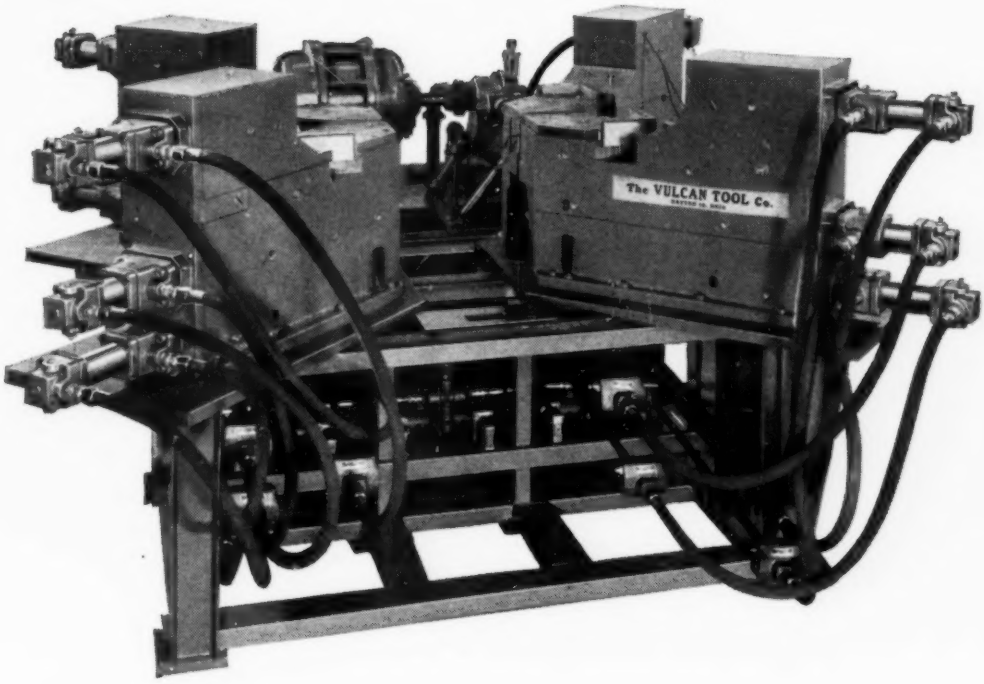

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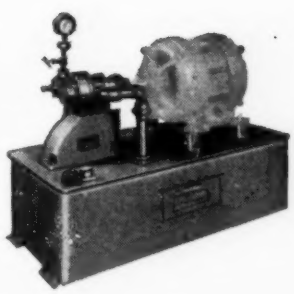

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GEROTOR

By CARROLL R. ALDEN

PACKAGE POWER UNITS SIMPLIFY MACHINE DESIGN

Hydraulic package power units offer the machine designer and production engineer the flexibility necessary for cycling variations including dwell and reversibility at any point, compactness, reliability and adaptability to practically any standard means of control. Package power units, "taken from the shelf", are applied without structrual alterations to a wide variety of high production machines.

CARROLL R. ALDEN

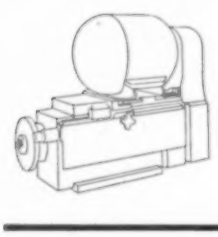
Mr. Alden is research engineer with the Ex-Cell-O Corporation, Detroit, Michigan.

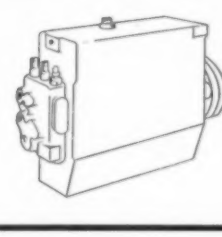
HIGH production special machines are basically a combination of three classes of structures: (1) the base and slides or table forming the backbone which houses or supports the operating mechanisms; (2) the tool holders and work holders which bring the tools and the work into working engagement, and; (3) the power supplying device and means for its control which determines the speed and sequence of relative movements of the functional parts. We will be concerned here with the third or power source structure.

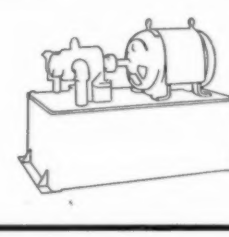
The design of the first two classes of structures are determined by the size, shape and material of the parts to be worked and the operations to be performed on them. The tools to be used and the operations to be done usually fall well within the knowledge and experience of the designer who can create the principal parts of the machine with rapidity and confidence.

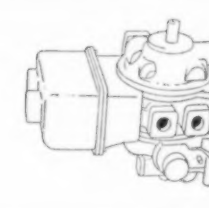
When a designer undertakes to design the means for power transmission and control he begins to "stick his neck out" and more often than not he spends several times as much effort on this class of structure than on the other two combined. Due to the fact that an individually designed and "hand tailored" power and control mechanism quite possibly may cost more than the rest of the machine, the designer naturally turns to packaged power units.

Package power units offer considerable advantages. Important among these is the technical progress made by unit controls through hydraulic, pneumatic, electrical means or a com-









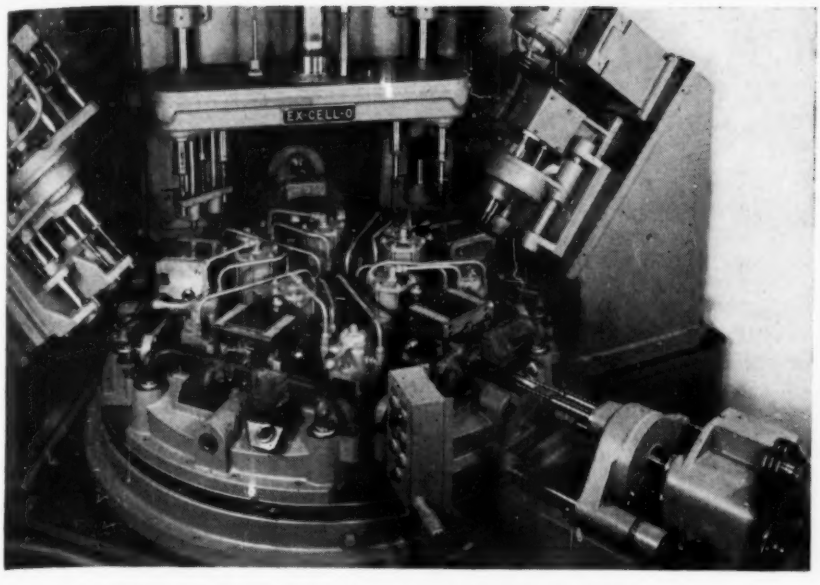


Fig. 1. This five station machine with automatically indexing work table has three hydraulic units (one in station 2, left; two in station 3, center) and two motor driven tapping heads (right). The work pieces are clamped by individually controlled air actuated fixtures.

bination of these by which the cycles of a number of units may be coordinated. Since modern production machines must frequently handle a sequence of precision manufacturing operations of considerable complexity, the control problem is one of critical importance.

Although some satisfactory package units are mechanically operated, more successful units on severe applications are hydraulically actuated. On hydraulic units the cycle can be changed readily to alter the length of stroke taken at various traverse speeds; the traverse speeds themselves may be altered and a dwell period, if required, may be provided without any structural alteration. Furthermore, hydraulically actuated units may be reversed at any time during the cycle, which is highly desirable in case of emergency.

Typical Power Unit

A typical hydraulic power unit is made up of a housing on which may be mounted a constant speed driving motor. The housing supports a rotatable tool spindle reciprocated axially in a quill which also forms the piston. With this arrangement the feeding pressure is substantially in line with the center of resistance. The reservoir, pump and control valves are enclosed in the unit housing.

In this type of unit power for rotating the spindle is applied through a spline which allows reciprocation of the spindle. Since it is important that the cutting pressure on the tools be applied concentrically on the spindle, it is advantageous that the spindle be located within the quill of the hydraulic unit. This makes it necessary that the forward spindle extension be included within the rod portion of the piston. It is likewise advantageous that the forward annular area of the piston (total piston area less rod area) be appreciably smaller than the rear piston area. A commonly used proportion is 50 percent.

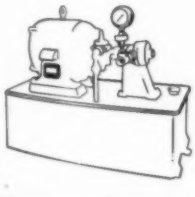
A schematic diagram of such a device is shown in Figure 1.

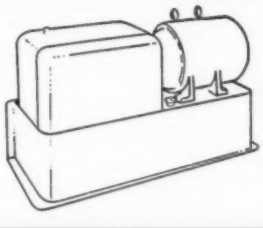
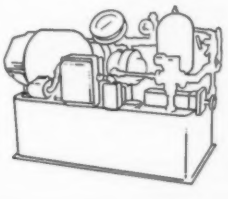
For maximum forward thrust on the quill and spindle and for maximum feeding speed, hydraulic fluid is admitted behind the piston and the area in front of it is connected to the return. Reverse quill movement is usually accomplished at rapid traverse. For rapid traverse in a forward direction both forward and rear piston areas are connected to pump, giving maximum rate of rapid traverse and minimum feeding thrust.

Forward feeding speeds are controlled independently by various means in hydraulic power units. Usually two alternatively selective feeding speeds are available. It is, of course, desirable that a reduction in feeding speed be provided by other than the wasteful expedient of dumping excess pump capacity. Such dumping tends to generate heat in the hydraulic system and to absorb an excessive power input.

For these reasons, the designer usually specifies a variable volume pump so that only the required volume of fluid to move the quill at the desired speed is delivered by the pump under any operating condition.

With one type of hydraulic power unit the reciprocating movement is imparted to the pump plungers by means of a pivoted swash plate which varies the stroke of the plungers from zero to maximum. Volume of pump delivery and rate of quill traverse may then be made



mutually responsive, at a rate of quill travel determined by the speed adjustment without regard to the forces opposing forward quill movement, within the capacity of the unit.

In the example cited (Figure 1), the reaction of both the spring and hydraulic pressure of the pump plungers tends to move the swash plate in the direction of maximum pump delivery. A balance piston and a control piston act on the swash plate in opposition to the plunger reaction. The balance piston is acted upon by the delivery pressure of the pump. The control piston balances the spring pressure acting upon the pump plunger. Pump delivery is made responsive to the speed of quill traverse. The fluid displaced by the advancing face of the piston is passed through an orifice of constant but adjustable area. Hydraulic pressure resulting from flow through this orifice is constant for any orifice setting, so long as the feeding speed is constant. Such setting is used for controlling the pump delivery. For this purpose the hydraulic pressure is applied on the control piston which forces the pump swash plate to the respective delivery position.

The quill has a tendency to increase its feeding speed when the resistance to forward movement is low. However, this causes an increase in the control pressure and the increased force applied to the swash plate by the control piston reduces the pump delivery. When increased resistance to quill movement is encountered the opposite action takes place. Should the axial movement of the quill approach a stall, the control pressure will approach zero. Maximum pump pressure is established by suitable valving. Therefore, the feeding speed of the quill may easily be adjusted by varying the flow area of an adjustable orifice. Two control orifices are provided for alternative use when it is desired to provide two independently adjustable feeding rates.

The dog actuated control valve, operating step-by-step, causes its rapid forward position to be followed by a first feeding position, second feeding position and, finally, by a rapid reverse position, returning the quill to its innermost at rest or stop position. As the control dogs are adjustable along the dog bar moved by the quill, the length of quill stroke and the quill positions at which its rates of traverse will automatically change, are subject to ready adjustment.

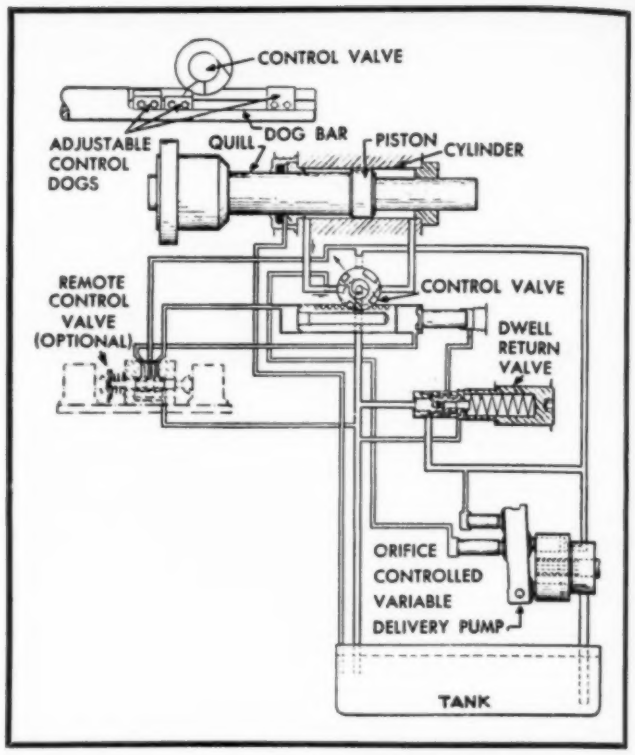


Fig. 2. The hydraulic arrangement for a typical metal cutting machine cycle.

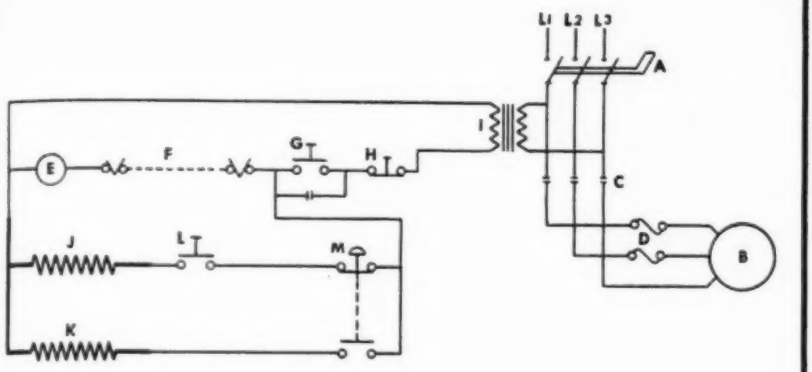
Precision Control

One of the outstanding advantages of hydraulic power transmissions is the ease, simplicity, economy and degree of exactitude with which they may be controlled. The small packaged power unit, thanks to the fact that a broad range of applicability makes extreme care in their engineering possible, is for this reason produced in a volume of production which makes their manufacture economical.

All machines which are required to cut to a predetermined depth, as in counter boring, spot facing or chamfering, use a cutter which feeds axially into the work. This requires reversal at a positive or fixed stop after a "dwell" or time delay sufficient for the continued rotation of the tools to leave a smooth surface. To provide this action, a so-called dwell valve may be used. Such a valve also functions as a safety feature in that it acts as a pressure responsive automatic return to prevent a stall or excessive pressure on the tools.

The dwell valve shifts the main control valve into its reverse position at the end of a predetermined dwell valve traverse. The required traverse of this valve is resisted by a spring-opposed hydraulic piston. This piston is positioned so that fluid displaced in its movement passes through an adjustable dwell orifice.

During ordinary movement of the quill, this piston is prevented from moving by the dwell valve spring. When the quill touches the fixed stop at the end of its forward traverse, the pump pressure builds up and the piston of the dwell valve begins to move at a rate determined by the setting of the dwell valve orifice. This, of course, determines the duration the quill will



A. Line Switch
B. Unit drive motor
C. Starter contacts
D. Overload elements
E. Starter coil
F. Overload contacts
G. Starter motor button
H. Master stop button
I. Control transformer
J. Starting solenoid
K. Emergency return solenoid
L. Start cycle button
M. Emergency return button

Fig. 3. Electrical diagrams showing start and emergency return control in a representative machine circuit.

remain against the fixed stop. The maximum working pressure built up in the unit before reversal will occur may be predetermined by adjustment of the spring which opposes movement of the dwell valve. In this way the unit may be made automatically self-reversing. Both the inbuilt dwell and safety return controls may be made inoperative whenever it is desirable to control the dwell by some other equipment, e.g., when the standard reversal may cause interference with the machine units.

When remote actuation of the main control valve is desirable in instituting a cycle of unit operation, the valve may be shifted hydraulically. Any one of several hydraulic units in a machine may operate a pilot valve to actuate the control valves. Interlocking limit switches or relays actuated by any controlling condition are commonly used to actuate control valves. A simplified electrical diagram, Figure 2, shows a typical starting and emergency return control incorporated in a machine circuit. Electrical controls are extremely flexible and may be used to coordinate operations of almost any number of units to perform almost any conceivable cycle of operations.

Another multiple operation machine is shown in Figure 3. This machine drills and spot faces a hole at either end of a motor car exhaust manifold, drills and taps three horizontal holes and two angular holes. The machine has five stations; work pieces are held by individually controlled air actuated fixtures separately mounted.

Station No. 1 is the loading and unloading station.

On station No. 2 a single hydraulic power unit powers two drills to make angular holes.

Station No. 3 has two hydraulic units. One, horizontally mounted, drives three drills to drill the three horizontal holes. The other, vertically mounted, drives two groups of tools—one group performs the drilling, the other the spot facing operations.

A motor-driven tapping head taps the two angular holes in station No. 4; a horizontally mounted, individually motor-driven tapping head taps the three horizontal holes.

The hydraulic units of stations Nos. 2 and 3 provide both rotary and reciprocatory motion of these heads. At the start of the work cycle for each of the heads the quill of the hydraulic unit moves forward at rapid traverse. The drills operate through spring-urged drill bushing plates. Both bushing plates and drills move forward on guide bars simultaneously with locating pins which enter locating bushings in the work fixture. When the locating pin is home, the bushing plate has assumed its forwardmost position and the drills have all but reached work engaging position.

(Continued on page 14)

Fig. 4. An electrical control panel, showing the type used for coordinating subcycles of a multi-unit machine. This is the panel of the Ex-Cell-O carbide tool grinder.

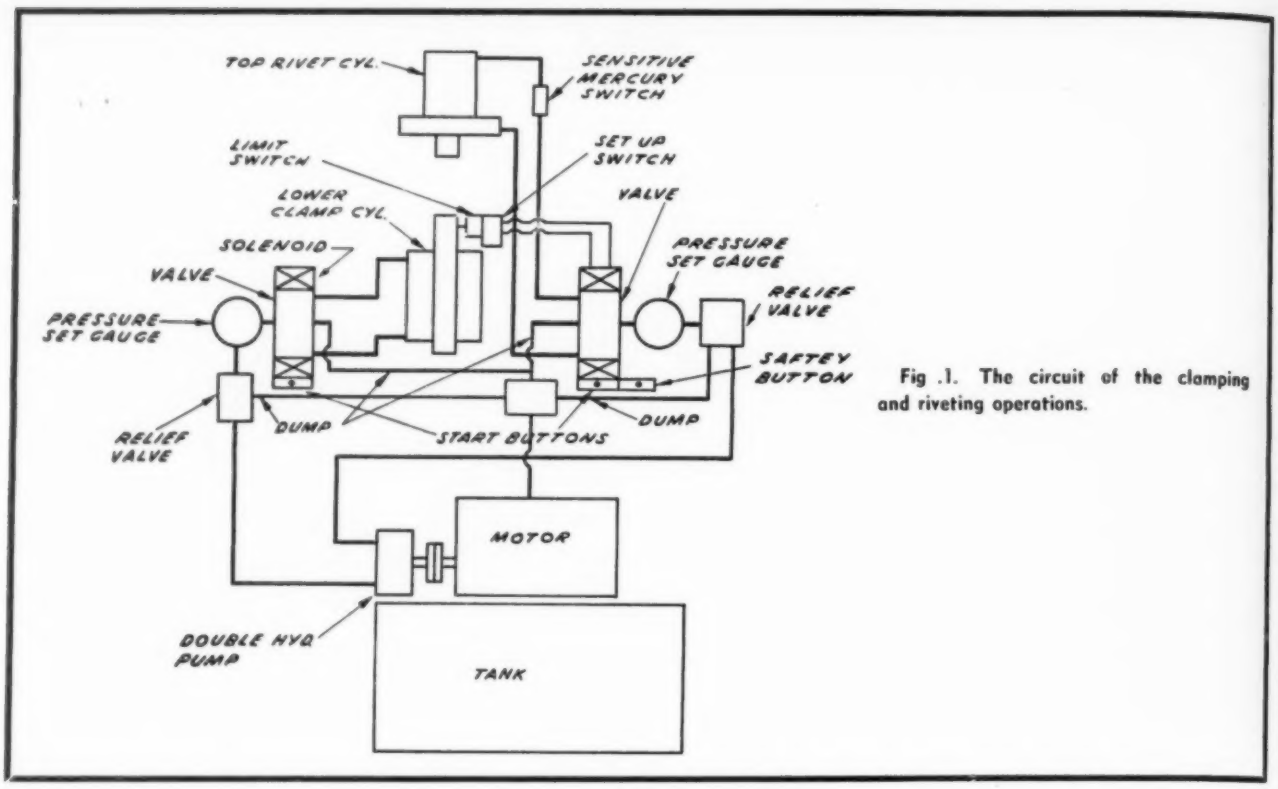


Fig .1. The circuit of the clamping and riveting operations.

A ONE-STEP ASSEMBLY

How a specialty jobber of electrical equipment gained in accuracy and speed of assembly, reduced scrap and changeover time and increased production by the use of hydraulically operated presses of their own design.

ELECTRICAL assemblies, by their very nature, have always entailed a considerable amount of hand work. In spite of many ingenious fixtures, the gathering of small parts, especially of dissimilar materials, that go into electrical assemblies still depends upon the skill of human fingers and on such uncertain variables as sight, memory and worker fatigue. This is true in contrast to the high precision demanded of completed electrical equipment. For this reason, equipment that reduces the element of human error in the electrical parts assembly field often means the difference between a profit and a loss.

Han-Kor Incorporated is an electrical specialty jobber shop. They are in a highly competitive field. As characteristic in this field, they employ many women and girls for parts assembly work. On the other hand, and whenever and wherever practical, they utilize the most modern and advanced machines to maintain the necessary close limits, to increase and hold a desirable production rate and to increase the flexibility of output required in their type of operation.

Punch presses are widely used for clamping and riveting commutator assemblies. In this company the selection of hydraulically operated equipment was a deliberate choice. The advantage of smooth, flexible quick action without vibration was considered important in the accuracy of clamping and the full control of the progressive riveting stroke. This organization believes that this method of assembly means longer life for their commutators. This advantage plus the simplicity of structural design, low power and maintenance cost inherent in hydraulic power has sold them on hydraulic actuation. They also use hydraulic broaches of their own design, hydraulic feeds on their strip machines and on various equipment in their tool room.

One such machine is used for riveting a loosely gathered as-

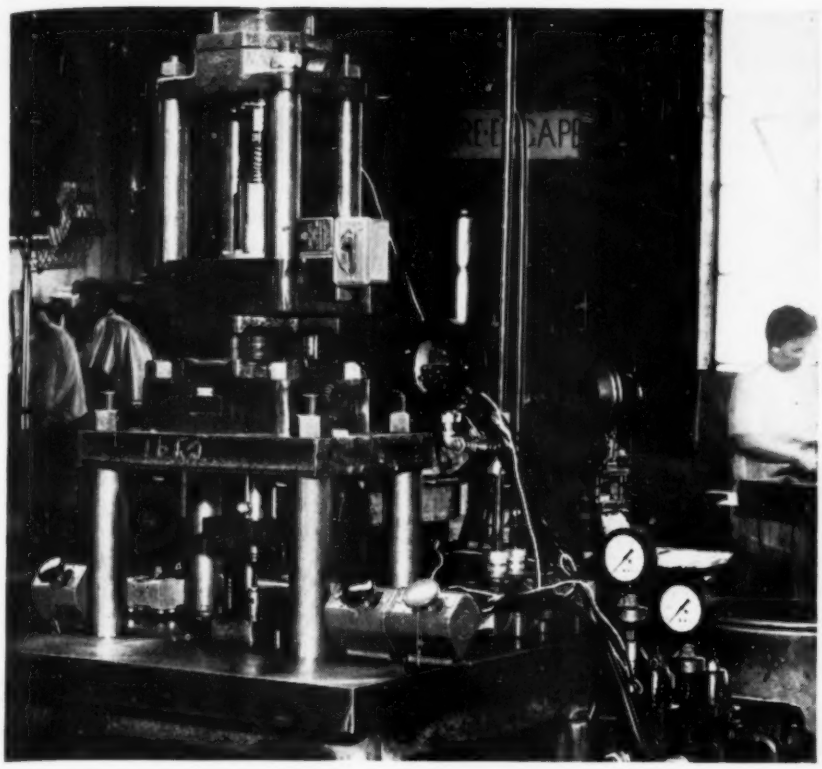


Fig. 2. The newest design of the special press is fully automatic with double solenoid operated valves.

sembly of parts of small commutators. The copper segments, insulator separators, rings and spools are gathered by hand and temporarily held together by only a rubber band. The riveting operation, performed on the press, is critical in the assembly. The final finishing and inspection operations are routine if the clamping and upsetting or riveting operations are done properly.

This operation, or operations, since there are actually two operations, a clamping and a riveting operation, are performed on a special assembly press. Basically, the press is a die set equipped upsetting press. The special features are the design and operation of the two hydraulically operated cylinders. A lower clamping cylinder operates to hold down the assembly by seating against the end ring of the commutator. An upper upsetting or riveting cylinder lowers to engage the head of the punch which extends through the length of the clamping cylinder; the lower end of the punch accomplishes the riveting operation.

The special clamping and riveting press designed for hydraulic operation was developed by Han-Kor engineers. The hydraulic circuit, through experience with earlier models, has been simplified by the use of one power source instead of two and by the adoption of solenoid operated valves instead of hand operated valves. The latest machine circuit will be described with references made to the earlier models.

The press with motor and pump located on the tank at the rear is mounted on a frame that brings the die set loading position to convenient table height. A die is provided for each size of assembly. The normal range of diameters of the assemblies is such that a single size bolster plate and die set can be used. The variations in die height are within the range of adjustment of the clamp and punch.

With the die open and the cylinders in their starting or fully retracted positions, the operator places a loose assembly on the die set. She presses both start buttons. This causes the machine to go through one complete cycle. The double solenoid 4-way valves function in sequence—the left valve lowers the outer clamp cylinder. The wall thickness of the clamping end assures that there is contact only on the holding ring. The lower clamp cylinder travels a preset distance and then actuates a limit switch which operates the right hand solenoid valve. This valve controls the top or riveting cylinder which then moves down, contacts the head of the punch and drives the punch against the projecting end of the spool. This action upsets the spool end sufficiently to seal the assembly together. A mercury type pressure switch reverses the operation when the preset pressure is reached.

The safety or emergency button is on the right side of the machine beside the right hand start button. By touching this button the cycle can be stopped at any point. This reverses the valves and both cylinders return to their starting position. On earlier models the machine would go through a complete cycle once the starting handles were moved. The ability to stop the cycle at any point gives the operator an opportunity to reset an incorrectly placed assembly; it is also an advantage which speeds up changeovers and adjustments by the setup man.

Gauge pressures are adjusted by hand operated valves when a job is set up and do not change through a given run.

The newest press is powered by a 15 hp motor which drives a double pump each unit of which delivers 12 gpm at 1000 psi. The control setup actuates the clamp and riveting cylinder in turn. In the older presses separate motors and pumps are used for each cylinder circuit.

Hydraulic operation, with sensitive controls, reduces the wear on work performing parts of the machine. Die sets have a

(Continued on page 24)

AIR STRETCHES OUTPUT

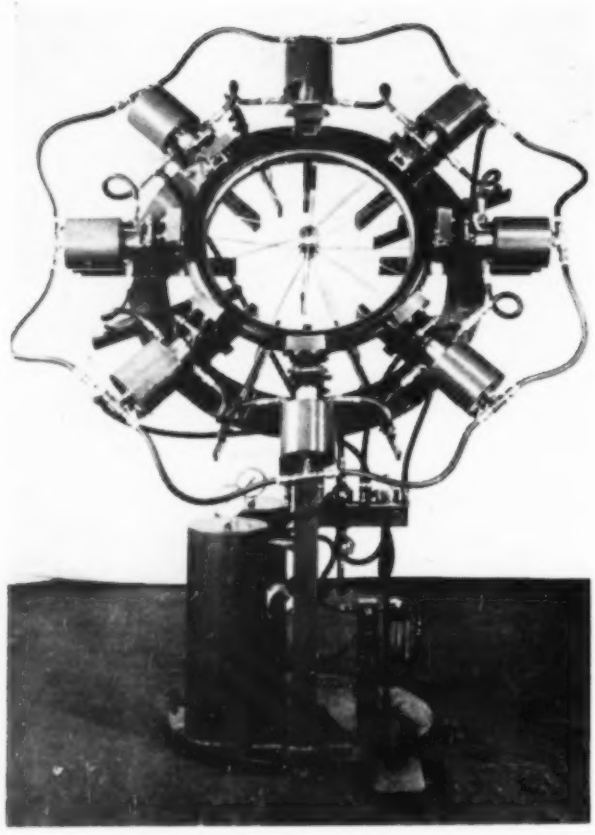


Fig. 1. The clamping and stretching machine for single operation mounting of one-piece moulded tires.

The use of air power for operation and control of these tire mounting machines has made possible high production rates and simple machine operation and maintenance.

THE HIGH operating speed of tire mounting machines developed by Evanston Mfg., Inc. of Detroit is due mainly to the incorporation of air-return and integrally built combination air cylinders and specially designed air operated control valves.

One-piece moulded tire stock and extruded tire stock with wire inserts can be mounted directly to the wheels by using three machines of special design. The one-piece moulded tires are mounted on a single machine that incorporates eight radially mounted air cylinders for clamping and stretching. The extruded tire stock, with wire insert for securing the tires to the wheel, are mounted, wired and secured on two machines also of special design. The first machine clamps, stretches and twists the wire; the second machine closes the gap between the tire ends left by the first machine.

Mounting Moulded Stock

The mounting of one-piece stock requires the use of only one machine and one operator; the cycle is started by a foot operated control valve as on the other machines. When the operator steps on the pedal, the clam-shell clamps attached to the radially mounted air cylinders, grab the tire and stretch it until the wheel can be placed inside the stretched tire. The clamps then release the tire and it snaps into position on the rim. (See Figure 1).

The small air storage tank, shown in Figure 2, furnishes air for the wire stretching cylinders only. The pressures required for tightening vary from 25 psi for No. 16 wire to 70 psi for No. 11 wire. The larger or line pressure tank supplies air through a manifold to the control valves.

This clamping and stretching in practically one motion is due entirely to the combination air cylinders units used. Each unit consists of two cylinders in one —a small cylinder inside the shaft of a larger cylinder. The small cylinder produces the forward motion of the clamps and the larger cylinder stretches the tire after clamping. A smooth fast motion is obtained with this arrangement.

A high production rate, which is very important in the economical operation of any unit, has been obtained with this machine because it requires only one second to grab, stretch and release the tire. Good operators have been able to mount from 1000 to 1500 tires per hour

on sizes ranging from 5 to 20 in diameter.

Mounting Extruded Stock

When extruded stock with wire inserts are mounted, two machines are required with the first machine wiring the loose ends of the stock directly to the wheel. (See Figure 2). To do this, wire holding clamps operated by two cylinders and located on the main machine pedestal, hold the wire ends while two larger air cylinders mounted on angular arms stretch the wire until it is tight. The wires are then secured by revolving the head, shown in outline in Figure 2, through 180 degrees. This revolving motion is produced by another air cylinder mounted on the machine base. A cutter mounted in the revolving head then cuts the wire and the head returns to the loading position. This cutter is also air operated.

The operation of this machine is a little slower than the first machine; 1½ seconds are required to complete a cycle of operations.

Although the tire is now securely wired to the wheel, one more operation is required because a gap between the tire ends has been left by the wiring machine.

A second machine is used to close this gap. (See Figure 3). This machine is also air operated, incorporating four rollers actuated by the two cylinders and a vertical clamping cylinder for holding the wheel securely in the machine. The rollers, two on each side of the wheel, are attached to the rod ends of the air cylinders and are operated through a pivot arrangement. The cylinders are set at a slight angle in relation to the wheel and force the rollers to roll upward toward the top of the wheel and toward the gap in the tire. This motion forces the tire ends to close tightly together.

Air Operated Control Valves

The control valves incorporated in the machine circuits are air operated by small cylinders

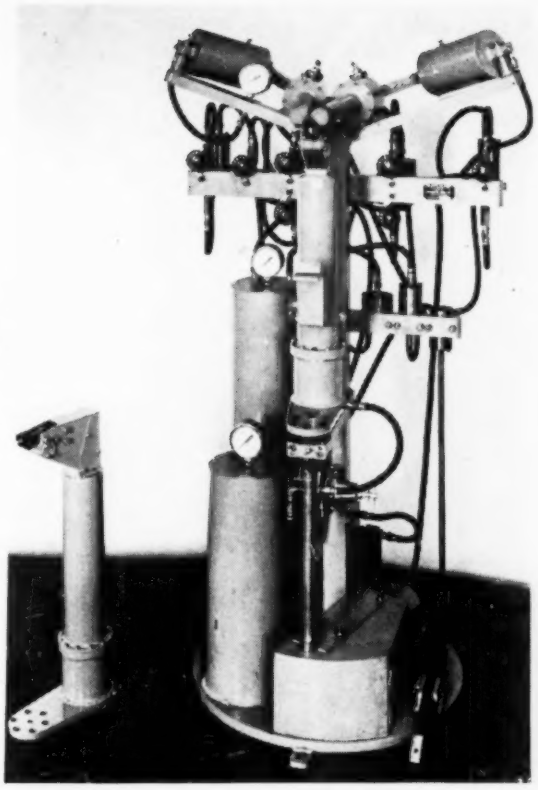


Fig. 2. The stretching, cutting and securing machine for first operation work in mounting extruded tire stock. A representative revolving head is shown next to the machine.

built in the valve body. A small cylinder is used to open the valve and a larger cylinder to reverse it. This difference in cylinder size eliminates the necessity for bleeding the small cylinder when reverse action is desired because the larger cylinder overcomes the pressure of the smaller cylinder and reverse action is almost instantaneous.

The valves are so constructed that exhausts are closed before intakes are opened; therefore, there is no escape of air except

(Continued on page 24)

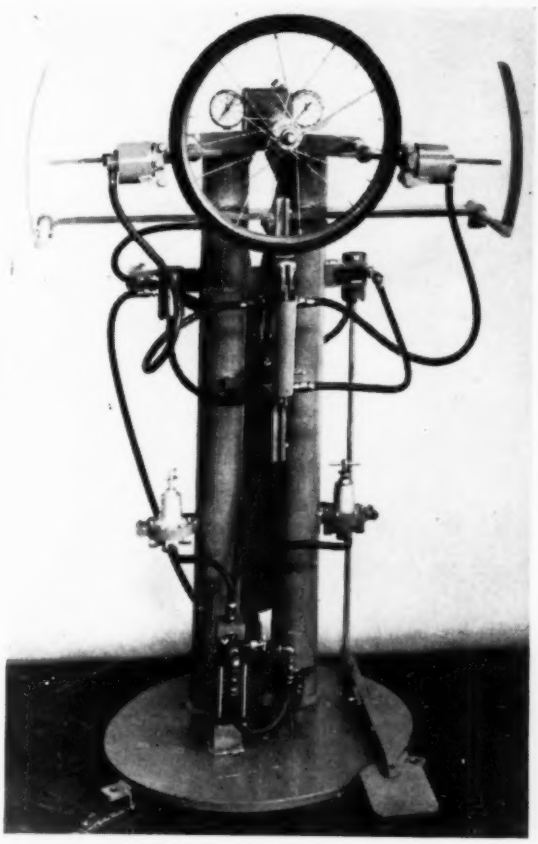
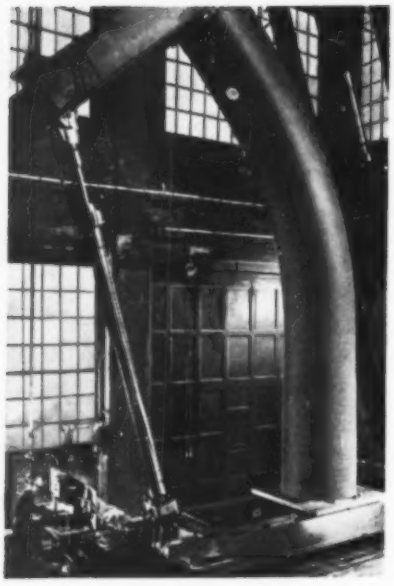


Fig. 3. The gap closing machine for the second and final operation in the mounting of extruded tire stock.



World's Largest Pipe Bending Machine

A HYDRAULIC machine for bending pipe in diameters up to 100 inches is in operation in the plant of The M. W. Kellogg Company, Jersey City, N.J. The new technique makes it possible to form one piece bends of uniform contours, with no out-of-roundness and no variations in wall thickness and to handle a range of sizes never before attempted.

During the war new petroleum refining plants required larger diameter piping—three, four and even five feet in diameter—larger than any existing bending equipment or procedures could handle. The existing equipment was able to handle sizes up to 30 or 34 in by using a thicker wall. Pipe bends or radii in sizes larger than this had to be fabricated of segments welded together. The new technique was first applied to a thin walled stove pipe, six in diameter and 1/13 in thick. No sand filling or support of any kind was used. Next, a 24 in pipe, 3/8 in thick was successfully bent into a tight three-diameter radius bend. The real test came with the bending of a 60 in pipe of only ½ in wall thickness. In spite of the fact that a 30 in pipe of ½ in wall thickness had never been bent previously without buckling, the job was successful.

The design of the new hydraulic bending machine was completed; the hydraulic pumps, cylinders, special heating equipment and electronic controls assembled; and construction of the machine begun in April 1947. Six months later the first pipe bending project was completed in the new machine.

One spectacular penstock job for a hydroelectric power plant was a 48 in diameter pipe only ½ in thick.

The new technique bends pipe in the hot state with hydraulic pressure. In a typical job, a straight length of pipe 30 feet long and 50 in diameter is placed in the pipe bender with the aid of an overhead crane. Heat is applied until a metal temperature of 1450 F is developed. At this temperature the yield point of mild carbon steel is reduced to approximately ten percent of the room temperature value.

Hydraulic loading is then applied until the pipe receives its calculated bend. A contour accuracy of .05 degree is achieved by the electronic controls. After bending, the pipe is heat treated so that the stresses remain uniform throughout the bend. The pipe can be loaded and positioned, bent and removed in less than a working day.

The process may be profitably used wherever a change in direction of a pipe line over 34 in diameter is required. Other possible applications for this process are for water circulating pipe in steam power plants, long distance gas lines, penstocks for hydroelectric plants, wind tunnels and other testing plants.

PACKAGE POWER UNITS

(Continued from page 9)

At this point a control dog on the hydraulic unit causes the quill to move at feeding speed and the drills move through their respective guide bushings to the desired depth into the work. The relative movement between the drill head and the bushing plate is taken up by a spring-resisted movement along the guide bars. At the predetermined forwardmost position of the unit quill, a control dog changes the movement to rapid reverse traverse. The bushing plate and locating pin remain in position until the spring has extended to a predetermined limit, when a sliding link picks up the bushing plate and locating pin and withdraws them to their starting position determined by the fully retracted position of the hydraulic unit.

The vertically mounted hydraulic unit in station No. 3 is provided with a dwell period sufficient to allow the spot facing tools to clean up, thus avoiding ridges in spot-faced surfaces.

Each tapping head is reversed automatically when its limit switch is actuated at the end of its forward stroke and comes to a stop in its fully retracted position by the actuation of a second limit switch.

Each unit must actuate its limit switch at the end or fully retracted position before the succeeding cycle can begin. Electrical interlocks also prevent a cycle from beginning if the clamping fixtures are not in locked position.

Although the three hydraulic units and the two tapping heads have their own work cycles, the electrical control system organizes them into a complete machine cycle. This system includes a number of limit switches actuated by the hydraulic units and tapping heads, electrical controls for starting and stopping unit cycles, the operator's manual controls and a panel with relays and other auxiliary devices for coordinating the action of various automatic and manual controls.

VALVE-CONTROLLED SERVOMECHANISMS

A report of an investigation on the analysis of the dynamic behavior of valve-controlled servo cylinders carried out at Massachusetts Institute of Technology. Behavior was studied in terms of driving pressure, valve orifices, cylinder size, load mass and linkage ratio. The data has been rewritten to make it more useful in design.

By CHRISTIAN E. GROSSER
Professor
Mechanical Engineering
Syracuse University

Introduction

THE VALVE-CONTROLLED hydraulic servo system as illustrated in Figure 1, is the oldest "follow-up" control mechanism known to engineers. It is a mechanism that enjoys a wide range of application and can be found as a component in such different equipments as aircraft automatic pilots, hydraulic press pump-stroke gear, agricultural and earth-moving machinery, ship steering gears, power plant governors, heavy road-vehicle steering gears, gun controls and machine tools. British engineers early dubbed it "slave", and "slave-mechanism", although these terms have more recently been applied to all sorts of servo (closed-cycle control) systems.

"Slave" is a name strongly suggestive of the system's character and function, since it will obey faithfully the directing pilot motion of a control signal; it may be obtained in simple and rugged constructions, and it is inherently both responsive and highly stable. In the latter respects it is unique inasmuch as other control systems, almost without exception, represent a compromise between sensitivity and stability, whereas the system under consideration possesses both qualities together in a compatible relationship, unless it is badly misproportioned.

The combination of high performance and stability has been recognized by operators and engineers familiar with the device's operation and this quality is intuitively sensed by the designer. The reasons for, and the conditions which favor, good operation are the primary subjects of the discussion which follows.

Alternative forms of the valve-controlled servo are shown in Fig. 2; "a" being the rotary equivalent of the basic scheme of Fig. 1 and "b" being a simplified version of the linear form which is in common use for steering boosters and similar controls. The various elements comprising Figures 1 and 2 may be combined in other ways which will be obvious to the designer. The combinations there shown merely represent some extremes in the variety of arrangements possible.

A fundamental handicap suffered by the valve-controlled servo is its low mechanical efficiency, due partly to the fact that all kinetic energy accumulated by the mass components is inevitably dissipated as heat by the throttling action of the control valve orifices. Most other servo systems are regenerative by nature, and are able to recover some measure of their energy of motion, as their systems are brought to rest. With the valve control however, the throttling orifices not only dissipate energy in deceleration, but rob energy from the accelerating component of the liquid flow, and so further reduce the efficiency.

Very broadly speaking the efficiency of this type of servo has an upper limit of perhaps 50 percent, if a significant proportion of the driving pressure is used to perform useful work against a resisting load force. In the cases where no such work is done, but where the system is used solely to move an otherwise unretarded mass from one position to another, the efficiency is, per se, zero.

Other types of servo systems which employ variable speed transmissions (of the torque multiplying types) have an upper limit of efficiency which is the efficiency of the transmission itself, and a lower limit roughly equal to the transmission efficiency multiplied by itself (squared), if it is functioning only to accelerate and then

to decelerate a mass system between one position and another.

In consequence of its relatively lower efficiency the valve-controlled system is limited to small power magnitudes where operating cost is incidental to considerations of construction, simplicity, and low maintenance. But despite its low theoretical operating efficiency it is remarkably effective in situations where bursts of power at a high level are needed intermittently for short intervals, i.e., where the average power requirement is low compared with the peak demands. In such cases the combination having a small pump, unloading valve and a large pressure accumulator, operates with good economy as compared with the no-load losses of a continually idling transmission type system which depends only upon the output capacity of its prime-mover to supply the peak power demands.

Methods of Operation Analysis

The customary method of designing a follow-up valve-controlled servo system such as in Figure 1 has been to add excess area to the working cylinder, up to 100 percent above that necessary to overcome the maximum static load resistance R_{load}, as computed with the available pressure. In so doing there is assurance that the load may be held statically with a small valve opening (and consequently with a small "error"), and may be moved readily against the load resistance. The surplus pressure-force is counted upon to supply a satisfactory dynamic (accelerated) response to demands for sudden changes in position.

"Common sense" may approximate satisfactorily the amount of excess force required for adequate acceleration and recovery. Close fits and adequate overlaps at the valve and working piston seal surfaces are obviously necessary to retard the system mass when the recovery is almost completed, since it is obvious that leakage will diminish the cylinder back-pressures needed during the latter stages of deceleration. Leakage unquestionably permits undesirable "overshoot" and oscillation. Also, it is sensed by the designer that if the system mass is large and high performance is produced with much excess driving pressure, the retardation pressures will be high in a "tight" system, as the valve approaches complete closure near the end of the cycle. Consequently the strengths of the components must be high to withstand bursting. The size of valve openings and the line areas are usually calculated on the basis of the accepted fluid friction-loss allowances, at the flow rate called for by the maximum signal motion velocity.

In general, procedures such as the above are a sufficiently good basis for design when conservative approximations are made and when the servo is not stringently limited by considerations of cost, space, or weight. For further refinement the routine calculation of transient values of velocity, acceleration and pressures, is out of the question because of the complexity of the equations of motion, if one begins from fundamentals. The differential equation of motion which describes the dynamic response is classed by the mathematicians as "non-linear with variable coefficients" and as such no "formal" methods of solution are known. A further complication is that the equation changes its form from point to point during the motion. However, satisfactory solutions may be reached by making certain simplifying assumptions, since it has been found possible

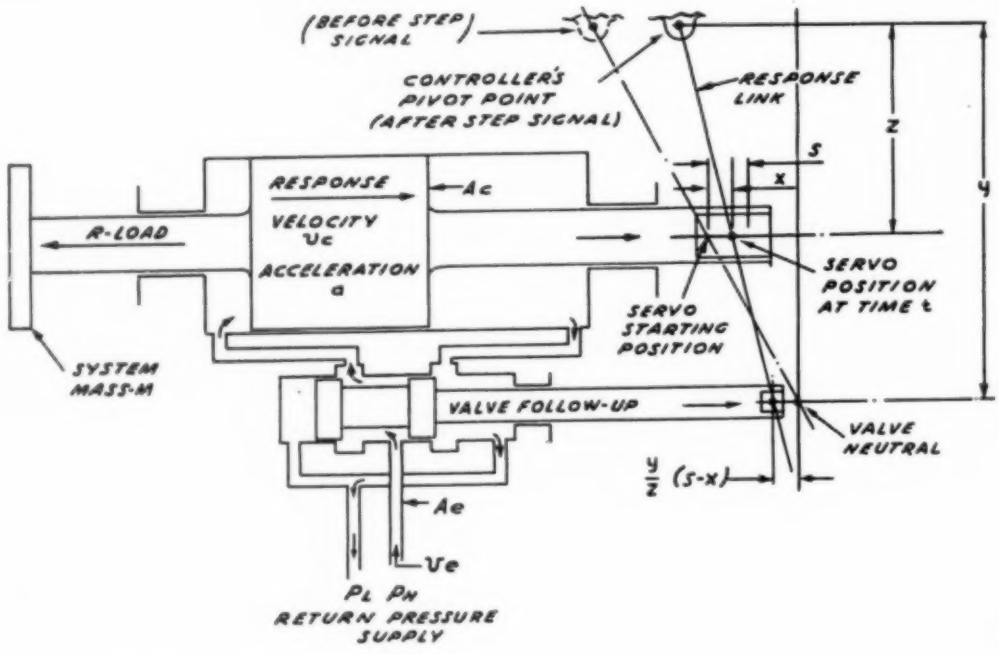


Fig. 1. Valve controlled servo system.

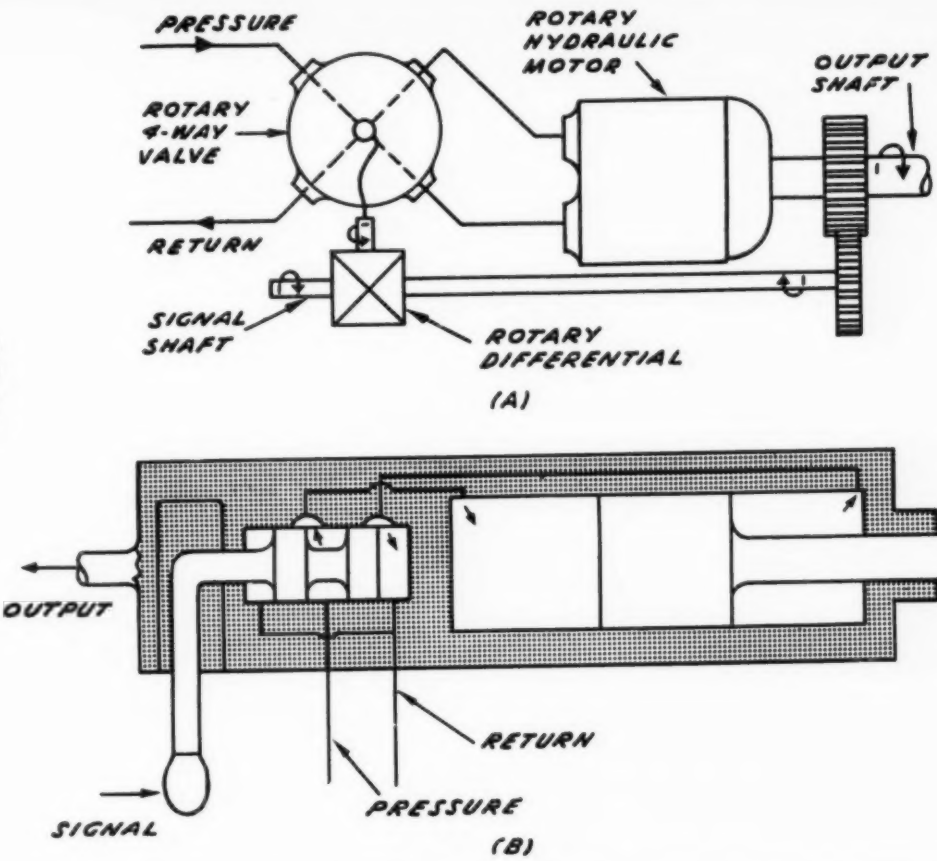


Fig. 2. Variations of valve-controlled servo arrangements; (A) rotary type; (B) "booster" type.

to reduce the motion equations to forms in which they may be solved in a somewhat tedious step-by-step technique, and the results then expressed in terms of ratios, rather than in specific quantities.

As a result a set of general performance curves have been found which provide a somewhat more definite basis for design and they may be applied to any given set of servo proportions, pressures, required performance, etc,. From these data one may approximate for a projected design: (a) time required to traverse a specified sudden displacement; (b) the consequent maximum pressures reached in the cylinder, valves and lines; and (c) to judge the general state of stability (tendency to oscillate or "hunt"). It is hoped that eventually this approach, which will be described below, may provide the means for developing a completely rational design of this type of servo and encourage more confidence in applications of the device, where the lack of data has been a deterring factor to its use.

Solutions of the fundamental equations above-mentioned have been tested by trials and measurements of a laboratory servo designed to meet as closely as possible the conditions assumed in setting them up.[1]

The Equation of Motion

The fundamental equation of motion for the system of Fig. I (also applicable to those of Fig. II with slight modifications) is written directly from Newton's 2nd law (F=ma):

$$M_a + R_{LOAD} = A_C \Big\{ \underbrace{(_pH - {}_pL)}_{\text{available supply pressure difference}} - \underbrace{\frac{\rho}{2} f \frac{L}{d} v_l^2}_{\substack{\text{pipe line friction} \\ \text{pressure drop}}} - \underbrace{nJv_l^2}_{\substack{\text{passage discontinuities} \\ \text{pressure drop}}} - \underbrace{[2] \frac{\rho}{2} \frac{1}{c^2} \left[\frac{A_l^2}{A_o^2} - 1 \right] v_l^2}_{\substack{\text{control valve throttling} \\ \text{orifices pressure drops}}} \Big\} \quad (1)$$

in which:

$p_H - p_L$ = effective pressure difference available at power source;

ρ = mass density of fluid weight per unit volume divided by gravity acceleration "g");

v_l = liquid velocity in pipe lines;

f = pipe friction factor (may be assumed constant = 0.03);

L = total length of pipe;

d = pipe line diameter;

J = average pressure loss factor at a contraction or enlargement (probably of the order of .75);

n = number of sudden contractions or enlargements in the system (generally about 10);

c = coefficient of contraction of the liquid stream in passing through the rectangular valve orifices, (generally close to 0.6);

A_l = area of the pipe line $(\frac{\pi d^2}{4})$;

A_o = instantaneous valve of valve opening area (this is limited to a maximum value equal to A_l since it is pointless to have a valve opening larger than the pipe which connects with it);

A_c = effective working piston area—the cylinder area less rod area—assumed the same for both ends for the sake of simplicity and usually justified since tail rod area is generally small compared with cylinder area;

M = moving mass of system (including load mass);

a = instantaneous value of the mass acceleration;

R_{load} = resistive force of the load opposing the motion.

The above equation is simply the expression of the fundamental law of dynamics, that a mass is accelerated by an amount equal to: the resultant acting force divided by the mass quantity. All factors are taken into account in the equation. Elsewhere this writer has gone into somewhat more detail in the derivation of this equation.[2] The equation was developed there for the special case of a particular servo with given proportions and under specified conditions regarding pressure, load, and liquid density. In this analysis it is intended that results applying to a wide variety of proportions and conditions will be made available.

Equation (1) may be transposed into the form

$$\left[\frac{M_a}{A_c}=\left\{\frac{p_x}{\left(p_H-p_L-\frac{R_{LOAD}}{A_c}\right)}\right.\right.$$

$$-[2]\frac{\rho}{2}\frac{A_l^2}{A_o^2}\frac{v_l^2}{c^2}$$

$$\left.\left.-\left[f\frac{L}{d}+n-J-\frac{1}{c^2}\right]\frac{\rho}{2}v_l^2\right\}\right. \quad (2)$$

The term $\frac{R_{load}}{A_c}$ represents the portion of available pressure necessary to overcome the load force resistance. Simplifying the picture sufficiently to obtain a result which shows primarily the dynamic effect of the excess pressure over that necessary to oppose the load resistance R_{load} we conservatively replace R_{load} by a **constant pressure** which will be the maximum load resistance $R_{load\ max.}$ under the condition that the load resistance always **opposes** the motion specified by the operator's signal.

The term $\left(p_H - p_L - \frac{R_{load}}{A_c}\right)$ will then be replaced by

$$\left(p_H - p_L - \frac{R_{load\ max.}}{A_c}\right)=\left(p_x\right),$$

which we shall call the **pressure excess** over that needed for static equilibrium.

The equation is then:

$$\frac{M_a}{A_c}=\left\{p_x-[2]\frac{\rho}{2}\frac{A_l^2}{A_o^2}\frac{v_l^2}{c^2}-\underbrace{\left[f\frac{L}{d}+n-J-\frac{1}{c^2}\right]\frac{\rho}{2}v_l^2\right\}}_{\text{to be neglected}} \quad (3)$$

It may be reduced to:

$$\text{acceleration}=a=\frac{A_c}{M}$$

$$\left\{p_x-[2]\frac{\rho}{2}\frac{A_l^2}{A_o^2}\frac{v_l^2}{c^2}\right\} \quad (4)$$

without loss of significant accuracy since the substitution of normal values for f, $\frac{L}{d}$, n, K, and c (see references 1 and 2) will show that the neglected terms which represent line loss, shock loss and part of the valve orifice loss are always small compared with at least one of the terms retained, during response to a signal for a sudden change in position. This kind of motion is called an "indicial response" and is the conventional standard of measurement applied to the dynamic performance of a servomechanism.

In the form of a differential equation we have as the equivalent of (4):

$$\frac{d^2x}{dt^2}=\frac{p_x\ A_c}{M}-\frac{\rho\ A_c^3}{M_c^2\ A_o^2}\left(\frac{dx}{dt}\right)^2 \quad (5)$$

in which x = linear distance moved by the servo piston from its starting position: and it is noted that by continuity of flow

$$A_l v_l = A_c v_c = A_c\frac{dx}{dt};$$

(the liquid being assumed incompressible).

Now A_o (instantaneous value of valve orifice opening) may be expressed in terms of the feedback linkage ratio $r=\frac{y}{z}$ (as shown in Fig. 1) and the position x of the servo output. The control valve ports may be reasonably assumed to have a maximum area equal to the pipe line area A_l; and also the conservative assumption is made that each port area is divided into two square ports diametrically opposite each other which balance the valve piston.

This assumption of a pair of opposed square ports serving as a control valve orifice is not actually a limitation on the results of the analysis. It represents a desirable design condition which may be analyzed readily in a straightforward manner. However, the results of this analysis may be interpreted accurately in terms of other port shapes including the usual annular grooves which extend completely around the bore of the valve cylinder. A detailed discussion of this consideration will be given below in the statement of results.

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[1] "Response Characteristics of the Valve-Controlled Servo", L. D. Lipschutz, M.I.T. 1943, M.S. Thesis.

[2] "Applying Hydraulic Circuits in Machines," MACHINE DESIGN, April 1942.

The concluding section of this report will appear in an early issue—EDITOR.

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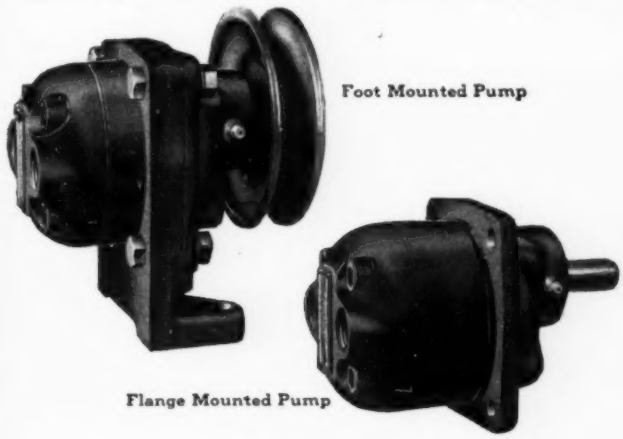

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The 100 Series HYDRECO pump is available in two capacities, 2.25 or 4.5 G.P.M. at 3000 R.P.M. at 1000 P.S.I. as a flange mounted pump or foot mounted pump with or without pulley. Pump has maximum resistance to adverse operating conditions . . . sealed outboard bearing on drive shaft takes side load pressure when pulley operated . . . anti-friction bearings on both drive and driven shafts . . . bronze wear plates for increased pump life. These pumps are used on P.V.T. 100 Group combinations.

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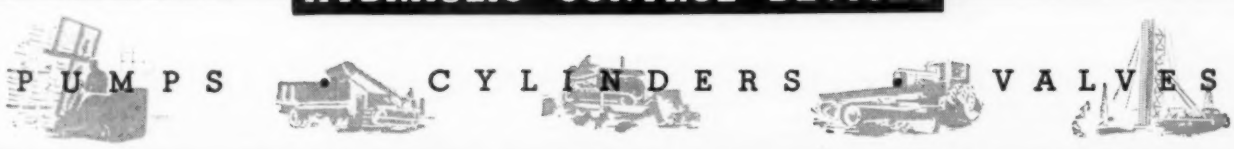

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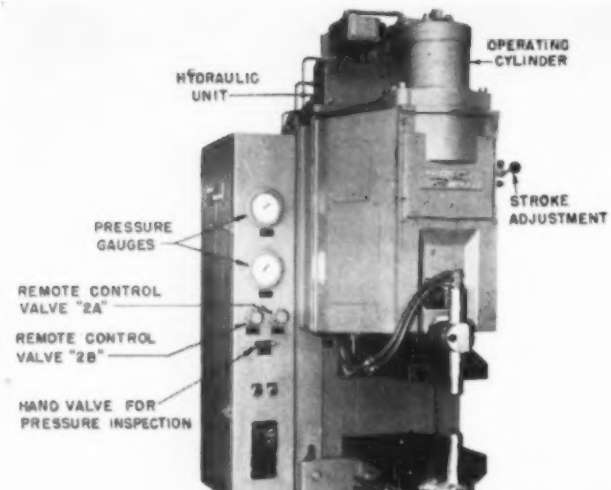


The hydraulic circuit described operates this press type welder.

RETRACTABLE STROKE CIRCUIT

A hydraulic circuit with adjustable and retractable stroke and a simple double pressure system for the operation of a press type welding machine. Other features include ram mounting on anti-friction cam follower type of roller bearings and packless type piston to minimize leakage. The adjustable and retractable stroke feature is applicable to many other types of machines.

By HANS H. HANSEN
Development Engineer
The Taylor-Winfield Corporation
Warren, Ohio

THE HYDRAULICALLY operated resistance welders (press type) made by the Taylor-Winfield Corporation embody several novel features, namely, a roller mounted anti-friction welding head, a no-ring or no-packing type of piston, adjustable and retractable stroke, and a simple double pressure mechanism.

In order to eliminate the friction that is apparent in conventional types of press rams, the ram is mounted on anti-friction cam follower type roller bearings. In keeping with the anti-friction design, a ringless or packless type of piston is used. The piston is ground to a very close fit with the cylinder and is of such a length (usually 1½ to 2 times the diameter) so as to keep the leakage to an absolute minimum. Concentric grooves evenly spaced for the full length of the piston act as balancing grooves and also leakage barriers.

The adjustable and retractable stroke feature of our welders can be readily and advantageously applied to other lines of machinery.

The prime purpose of the retractable stroke is to be able to instantly increase the stroke of the ram because of periodic work clearance obstructions or in order to readily service the welder electrodes or the work holding fixtures. The amount of stroke retraction depends upon the working stroke of the operating cylinder. If the total stroke of the operating cylinder is 6 in and the normal working stroke is 1 in, then the retraction stroke over the normal of 1 in will be 5 in. In other words, total piston stroke minus the working stroke equals the retraction stroke. The stroke adjustment and its relative amount of retraction can be done very simply by the use of hydraulics.

In the operation of our welders, a double pressure is sometimes required to give the correct operational characteristics. There are many welding jobs which require light welding pressure at the start of the weld cycle and at a precise instant during the welding cycle, a very heavy pressure must be exerted. Here again, this is done very simply and effectively by hydraulics.

General Description

In order to fully understand how the hydraulic system performs, the function mentioned above, we have prepared four diagrams, Figures 1, 2, 3 and 4, showing the press ram and its

operating piston in its various positions. These diagrams also show the various components of the system, their relative positions to perform the various functions and the consequent flow of oil.

Referring to all figures, the pressure oil is shown in double cross hatch; low pressure or exhaust lines are shown in single cross hatch; and trapped low pressure, non-moving or exhaust oil is shown void of all cross hatching.

Referring to any of the figures, the system consists of a motor, operating a single stage constant delivery vane type pump.

The main valve, (1), is a spool type, double solenoid, spring centered, 4-way valve.

The two relief valves, (2 and 3), are of the balanced piston type. No. 3 is used as a safety valve and is set permanently to relieve at 1,000 psi pressure. No. 2 is connected through a ¼ in solenoid operated 4-way pilot valve C to two (2) ¼ in remote control relief valves 2A and 2B. Valve 2A is to control the low initial welding pressure and the valve 2B is to control the high final pressure.

The hand valve H, is shown and is to shut the gauge off from the pressure when it is not being read in order to prolong the life of the gauge.

Needle shut-off valves are incorporated in the pilot lines so that the gauge and the pilot valves can be removed without draining the whole system of oil. This is especially advantageous where the remote control valves 2A and 2B are at eye level and the remainder of the system is overhead.

The needle shut-off valve (4) is also used to shut the pressure off from the remote control pilot system when it is desired to check the pressure setting of the safety relief valve (3).

Wherever possible, gasket mounted valves and manifolds were used for compactness and ease of maintenance. Steel tubing and compression fittings were used throughout in order to reduce friction to a minimum.

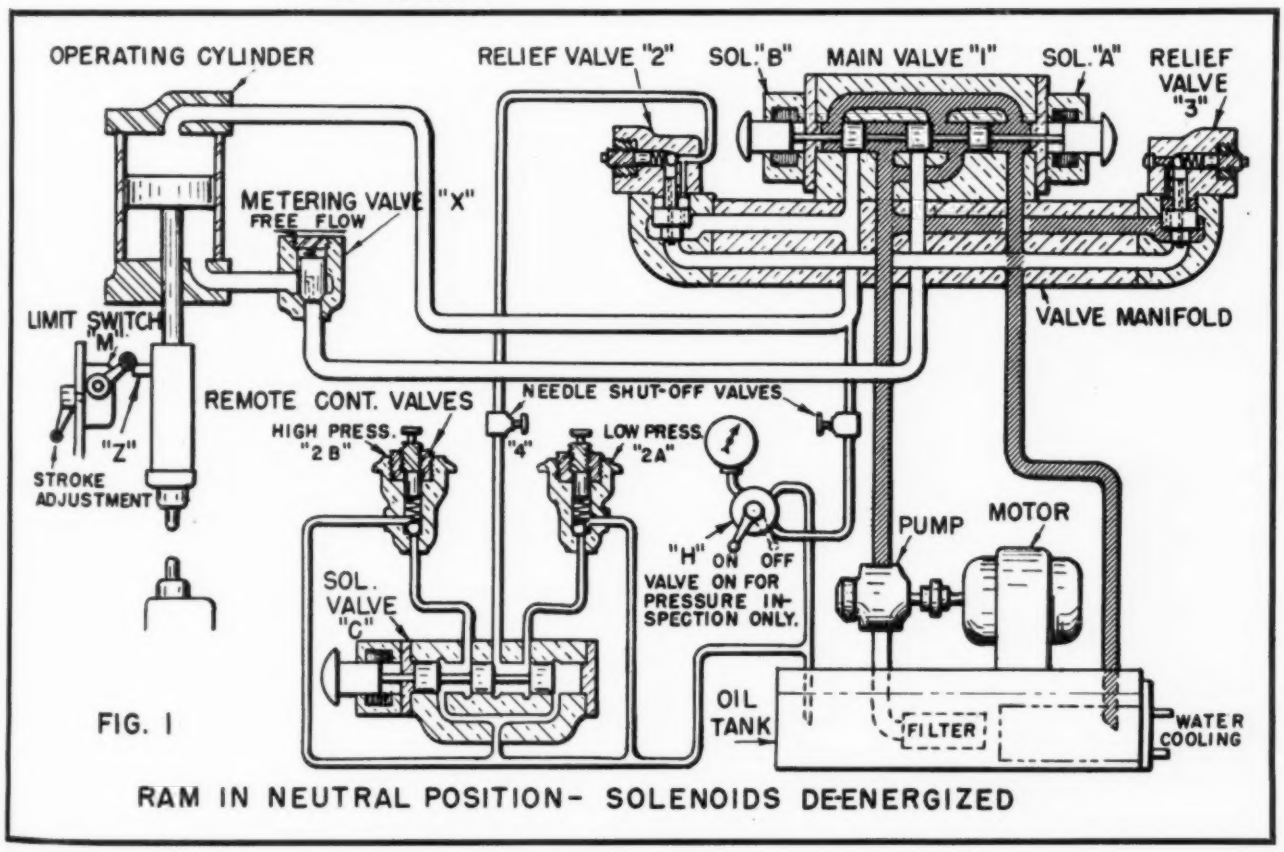
Sequence of Operation

Figure 1 shows press ram in neutral static position with solenoids A and B of main valve (1) de-energized. The spool of main valve (1) is spring centered to the position shown blocking both ports to the operating cylinder, thus holding the press ram in suspension. The spool position of the main valve allows the oil from the pump to circulate freely back to the oil tank.

Solenoids A and B are controlled by limit switch M which in turn is controlled by the movement of the press ram.

Figure 2 shows the press ram in the down static position. In order to bring the ram to this position, the operator depresses a foot switch, which energizes a time interval timer, and this in turn energizes solenoid A thereby by-passing limit switch M. The consequent position of the spool of main valve (1) allows the oil to enter the top of the operating cylinder and opens the bottom of the cylinder to exhaust. The ram moves downward until the welding

Fig. 1. Press ram in neutral position with main valve solenoids de-energized. The spool of main valve (1) blocks both parts to the operating cylinder.



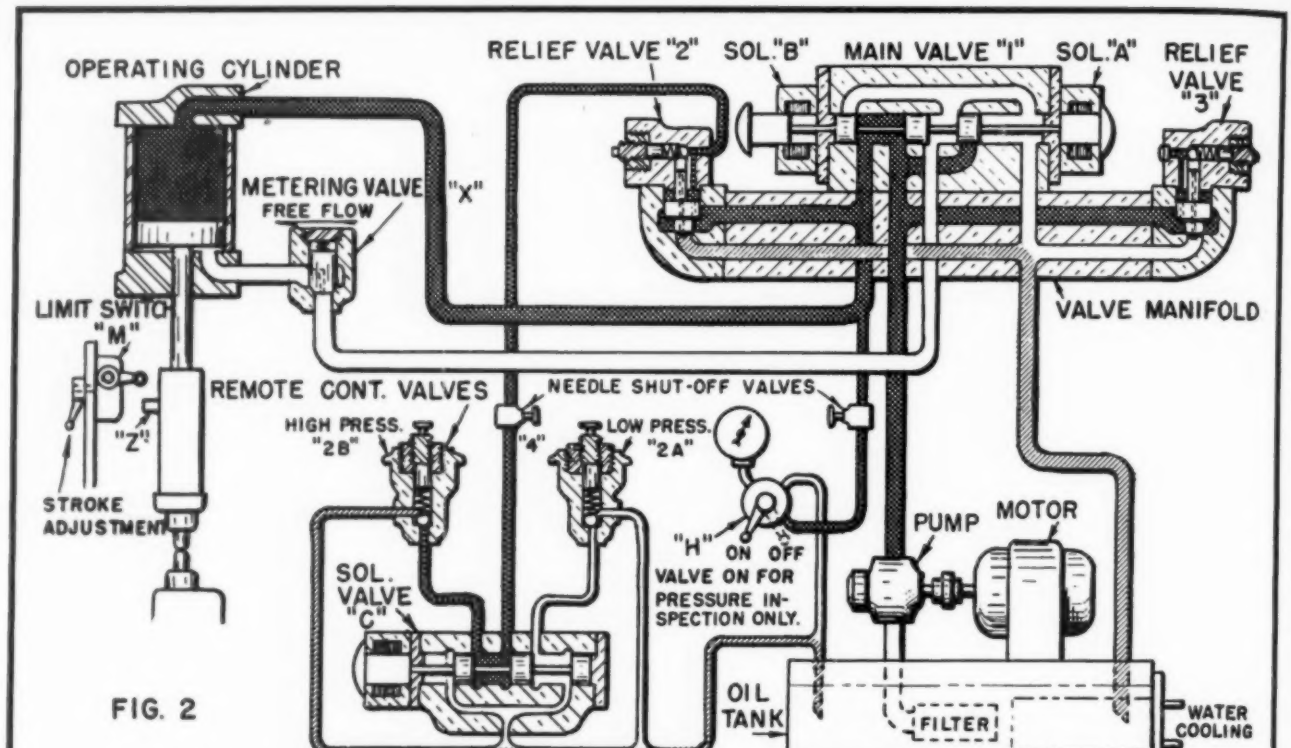
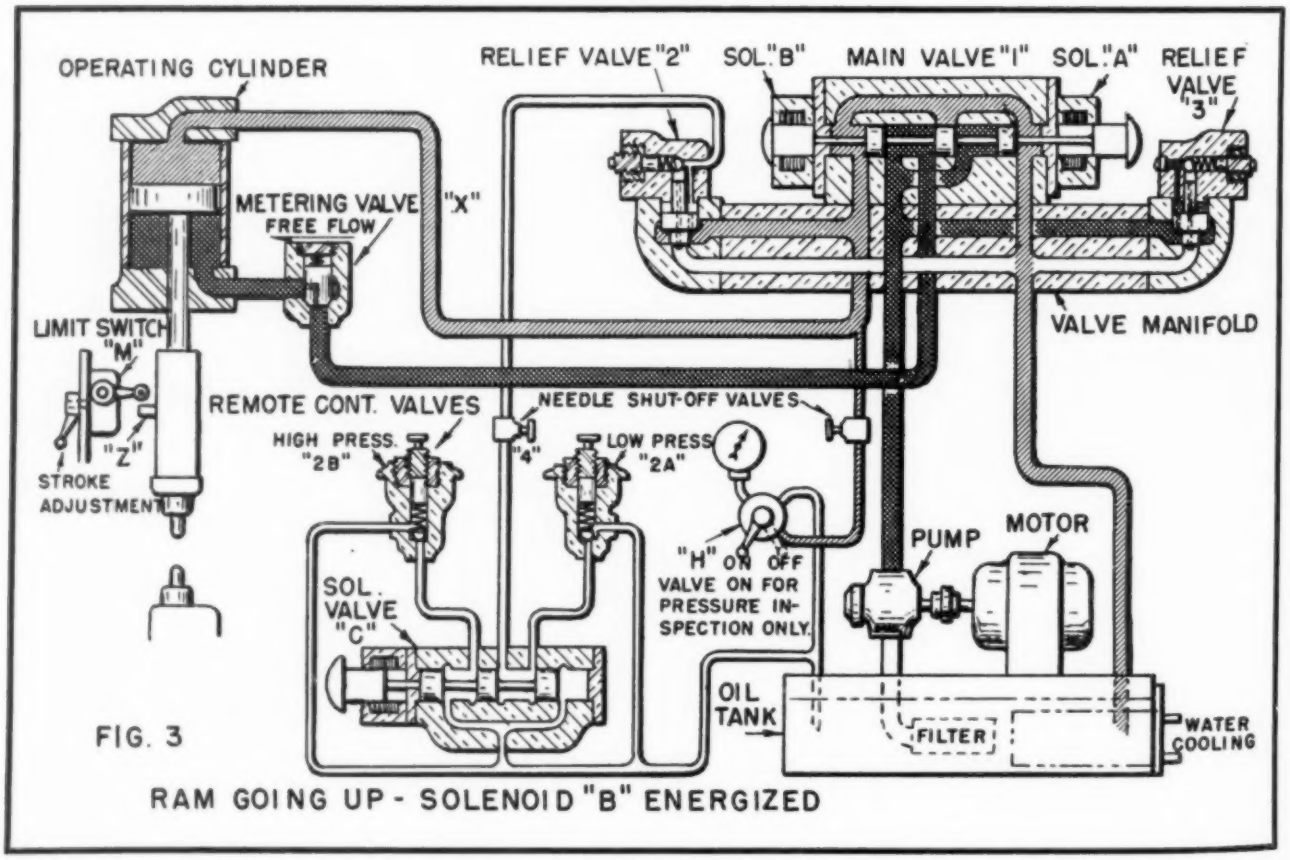


Fig. 2. Press ram in down position with welding electrodes in contact. Solenoid A is energized, then C, changing setting of relief valve (2) from low to high welding pressure.

Fig. 3. Press ram in the returning position. Solenoids A and C are de-energized, solenoid B is energized, reversing main valve (1).



electrodes touch. The downward speed of the ram is controlled by metering valve X which is so designed as to allow unrestricted flow during the upward stroke of the ram. When the electrodes come together, the oil pressure builds up to the pressure set by the low pressure remote control valve 2A.

After a set time, the interval timer energizes solenoid valve C, and thereby, changes the control of the relief valve (2) from valve 2A to valve 2B thus changing the setting of relief valve (2) from the low welding pressure to the high forging pressure almost instantaneously. The foregoing is a very simple effective way of obtaining this double pressure feature.

Figure 3 shows the press ram in the returning position. At the end of the weld cycle, the interval timer de-energizes solenoids A and C and energizes solenoid B, reversing the spool of main valve (1) thus opening the top of the cylinder to the tank and the bottom of the cylinder to the pressure, causing the ram to go up. The flow through the metering valve X is unrestricted in this direction.

The ram moves up until the stroke cam Z operates limit switch M. The position of limit switch M determines the working stroke of the machine. The stroke is adjusted by moving the limit switch and its bracket to different positions within the total stroke of the operating cylinder. Switch M de-energizes solenoid B and the main valve (1), being spring centered, centers itself and locks the oil in the top and bottom of the cylinder and opens the pressure line to the tank as shown in Figure 1.

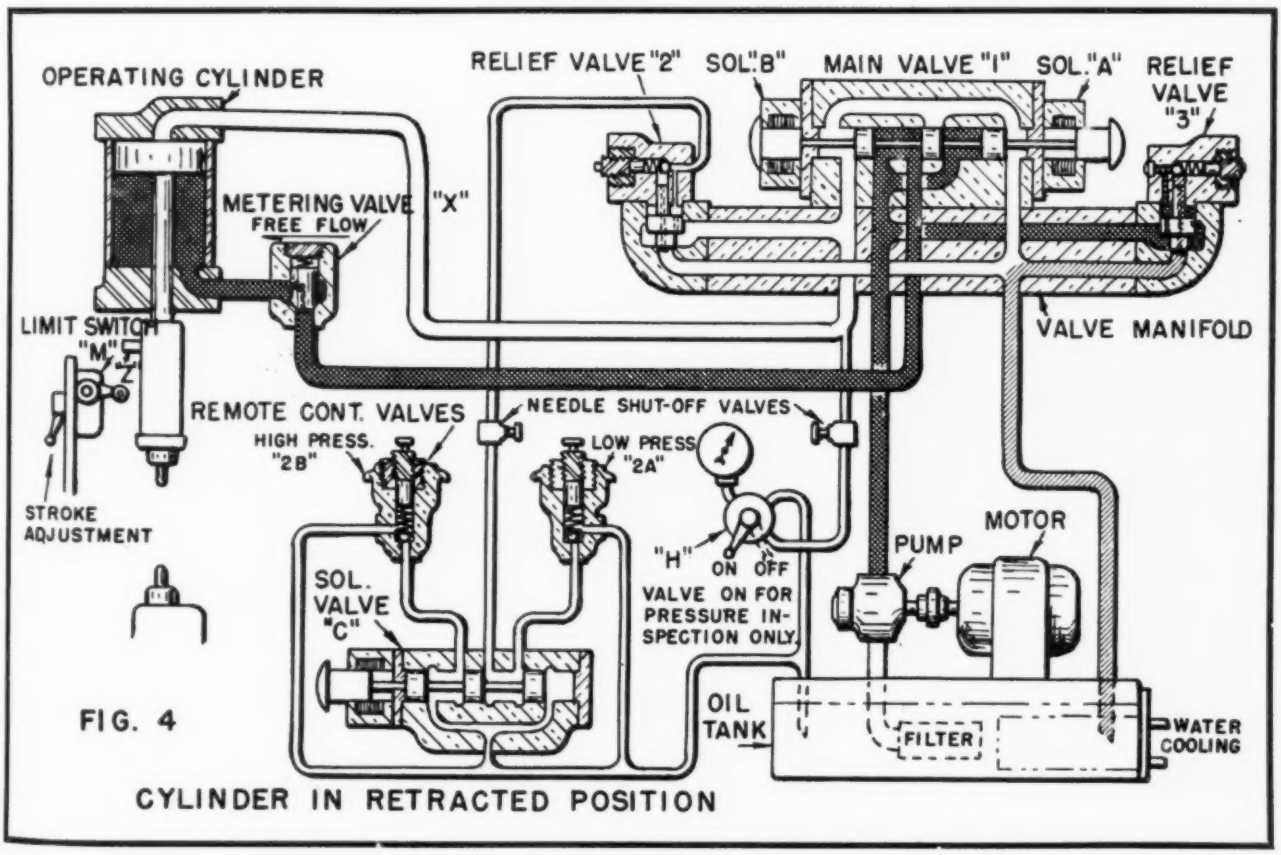
Figure 4 shows the press ram in the retracted position. In order to obtain the retractable stroke feature, a second foot switch is employed. By stepping on the switch, a ratchet relay is energized which in turn energizes solenoid B of main valve (1) thus allowing pressure oil to enter under side of piston and opening upper side of piston to exhaust. Operating piston then moves to the top of the cylinder, thus carrying the ram to its extreme upward stroke. In this position, the oil is relieved over relief valve (3).

To bring the ram back to its neutral or working stroke position as shown in Figure 1, the second foot switch is again depressed, thus reversing the ratchet relay which de-energizes solenoid B and energizes solenoid A which moves the spool of the main valve (1) to the position shown in Figure 2 thus putting oil into the top of the cylinder and opening the bottom to exhaust.

The ram travels down until the cam Z operates limit switch M. Solenoid A is then de-energized, valve (1) is then spring centered, again locking the oil in both the top and bottom of the cylinder and holding the ram in its neutral or normal stroke operating position.

For subsequent operation, the above cycle is repeated.

Fig. 4. Press ram in the retracted position. Operation of second foot switch energizes solenoid B, admitting pressure oil to enter under side of piston and opening upper side to exhaust.



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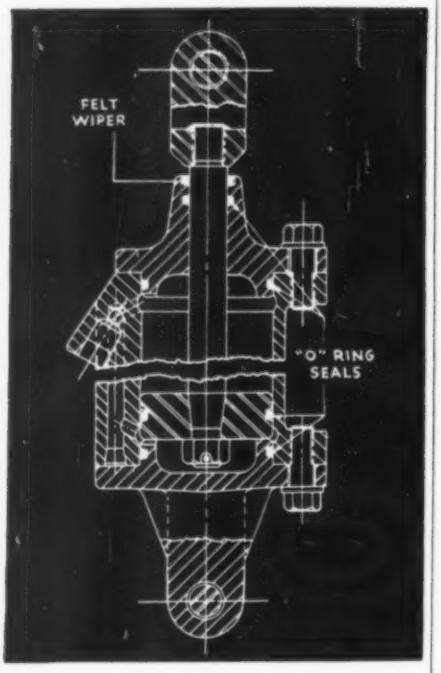

This 3½" x 8" Pivoting Type 1250 PSI Hydraulic Cylinder, used for hydraulic actuation and control of farm implements, meets Farm Equipment Institute Standards. In dirty, heavy duty service, it gives the equivalent of 5 years' servicee.

"O" Ring Seals are used on the piston, piston rod and end caps to simplify the construction and assembly, to decrease costs and give dependable long life. "O" Ring Seals are also being used in "package type" farm tractor lift systems on check, relief, unloading and sequence valves—gaskets, pumps and lift cylinders.

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A ONE-STEP ASSEMBLY

(Continued from page 11)

long accuracy life. This is important where the length of runs are variable and sizes cannot be anticipated in advance. With solenoid actuated valves with starting buttons for both hands of the operator, operation is perfectly safe for the operator and cycles are automatic. The press operates quietly, either with hand or solenoid actuated operation.

Operation is fast, the average clamping and riveting cycle being about 3 seconds in addition to the manual loading and unloading.

The Han-Kor organization has found the results they are getting with the hydraulic operation of these special assembly presses very gratifying. They have found that they are accomplishing faster and more accurate assembly, safer operation, greater flexibility in setup changeover, longer machine life, less downtime and more actual production time.

AIR STRETCHES OUTPUT

(Continued from page 13)

on opening of exhaust ports and valve operation is very quiet.

Practically instantaneous actuation and extremely quiet operation of these valves makes them important factors in the speed and ease of operation of the tire mounting machines.

The air pressure required for tire mounting operations varies from 90 to 120 psi and can be obtained from standard individual or centrally located air compressor power units.

The open design of the air circuits makes both preventive maintenance and trouble shooting relatively simple.

Continued use of these machines has proven the value of air powered operation and control. Operation is simple and quiet, maintenance is easy and production is fast and versatile because of the speed of mounting and the range of tire sizes handled. The combination of these factors has meant increased production and profits.

LETTERS to the Editor

We have several production machines to which hydraulic drives have been added on which we are encountering too much line breakage. Vibration seems to be the principle trouble. Most of our difficulties have been on small, high pressure lines. We have been given some conflicting advise about the type of tubing we should use, the routing of lines and the proper methods of tieing down lines. We need a "neutral" viewpoint to help straighten us out. Your suggestions will be welcome.

B.J.

Answer:

A "neutral" viewpoint on the sizing, routing and tieing down of hydraulic transmission lines is difficult because everyone concerned is interested in reducing vibration and static line resistance and in affording the maximum protection to operating elements in such a system. The engineering and service departments of hydraulic equipment manufacturers are the best first source of information. Production engineers or maintenance men who operate hydraulically actuated equipment could also be helpful.

Our maintenance men, unfortunately, are not very well grounded in hydraulic equipment. Could you recommend basic service manuals or industrial school text books that would be easy for the average shop man to follow to advantage?

Also as a suggestion, we would like to see more diagrams of hydraulic systems in APPLIED HYDRAULICS. We hope you are planning to include basic drawings and explanations of operation of pumps, valves, etc. This would be very helpful.

R.M.W.

Answer:

A number of the leading manufacturers of hydraulic equipment issued service or maintenance manuals and instructions which are regularly sent with equipment. The manufacturers' literature is the best available. At least two leading manufacturers make available or sponsor specialized training courses for maintenance or service men. Several large production manufacturers and assemblers have maintenance training programs for their own men.

We agree that diagrams of hydraulic circuits are very helpful to understanding operations and in running down difficulties. We will continue to publish them regularly in APPLIED HYDRAULICS.

We are engaged in the building of an entirely new machine. Any information you can give us as to how we can increase our knowledge on hydraulics would be welcome and we are interested in buying helpful books on the subject.

N. H.

(Continued on page 27)

SAVE THIS VALUABLE REFERENCE MATERIAL—BUILD UP A PERMANENT FILE

FUNDAMENTALS OF HYDRAULIC MAINTENANCE

By CARL LINDE,
Service Engineer
Rockford, Ill.

This is the first of six articles written by a service man for service men. Based on a wide experience, the series will treat the every day problems encountered by the hydraulic maintenance man and offer tested procedures and practices for their practical solution.

A GOOD MANY reports go across the desk of a Chief Service Engineer in the course of a year. They reflect an apparently wide variety of difficulties encountered by service men in the field.

Actually the difficulties listed are more apparent than real. Careful analysis of these reports indicates clearly that approximately seventy-five percent of the troubles reported can be listed under three easily prevented causes. Let's take a look at two of them in this article, and see how easily they can be handled. The third one will be discussed in a later article.

One important factor in the operation of any hydraulic equipment is the attitude of the men who service them. As reported by our field men these attitudes fall into three general classifications.

First, there is the maintenance man who is afraid of hydraulics. He doesn't really understand the basic functions that govern the operation of hydraulic equipment. Consequently, when something goes wrong, he "guesses" that changing this or that will end the trouble. Needless to say, it does nothing of the kind.

There is no need to be afraid of hydraulic equipment. It is simple to handle and simple to keep in perfect operating condition if the maintenance man will learn the few basic facts that are required and will then follow up his knowledge. Hydraulic engineers—like engineers in every other field—have done all the hard, difficult jobs and have presented industry with highly efficient machines that are as nearly foolproof and trouble-proof as it is possible to make them.

Second, there is the maintenance man who contemptuously regards hydraulics as too simple to require any thought on his part. He has always been able to fix anything else with a hammer, a wrench, and a screwdriver, and he ought to be able to maintain a hydraulic system in the same way.

Third, there is the maintenance man who recognizes hydraulic systems as a highly important contribution to the efficiency of modern machinery in a wide range of industrial applications. He realizes that hydraulic equipment makes his maintenance job easier because hydraulic pressure cushions the equipment for which he is responsible against shocks, thus eliminating unnecessary wear and tear; because hydraulic applications eliminate a multiplicity of gears, cams, and levers which are a constant source of trouble in older types of equipment; because properly serviced hydraulic equipment requires very little actual maintenance work, thus reducing the "down time" of a machine and consequently making the maintenance man a prime favorite with the boss.

Such a maintenance man knows that the operation of hydraulic equipment is controlled by certain basic principles just as is true with electrical equipment. In fact he recognizes that there is a certain kinship between these two forms of power. He readily associates voltage with hydraulic pressure; amperes with hydraulic volume; the ohmns laws of resistance with the law of fluid viscosity. In other words, he fits himself for the job.

SAVE THIS VALUABLE REFERENCE MATERIAL. BUILD UP A PERMANENT FILE

Undoubtedly there are thousands of such maintenance men. We never get to know them well because they so seldom find it necessary to call on us. But we do know there is a crying need for thousands more like them—maintenance men who have taken the trouble to learn the comparatively simple fundamentals of hydraulics. When that happens, the maintenance of hydraulic equipment will prove to be a minor problem. But not until then.

The second important factor in the successful operation of hydraulic equipment is the use of a properly selected hydraulic oil.

Any reputable manufacturer when shipping a piece of hydraulic equipment recommends the hydraulic oil he considers best for its most efficient operation. This recommendation is based not on whim or fancy or personal likes, but upon thousands of costly experiments made by him, by other manufacturers, and by all the important oil companies. It is a carefully considered recommendation because the manufacturer knows he can not sell equipment that does not function properly, and he knows that no hydraulic equipment can function properly with a poor grade of hydraulic oil.

Years of experiment have proved that there are four qualities which a hydraulic oil must have if trouble-free operation of hydraulic equipment is desired.

First, a good hydraulic oil must be unusually resistant to chemical change.

Two factors are chiefly responsible for the tendency of hydraulic oil to change its chemical composition. One is the constant churning in the presence of oxygen as the oil circulates through the system; the other is the fact that oil is apt to lose its desirable characteristics when exposed to high temperatures.

When the chemical composition of an oil changes, it is readily detected by a change in color and sluggishness of the fluid. This is the result of sludge or gummy deposits in the oil, which is caused by a combination of oxygen with some chemical substance in the oil. Naturally, sluggish oil retards the operating cycle and slows down production. Eventually sludge or gummy deposits interfere with the action of the machine.

Since oils differ widely in their chemical composition, it is necessary to choose such oils as offer a high degree of resistance to the chemical changes just discussed.

Second, a good hydraulic oil should have a high degree of demulsibility.

To put it simply, this means that the oil should have the ability to separate quickly from moisture which may work its way into the hydraulic system of a machine. When this separation takes place quickly, the water settles on the bottom of the reservoir and is not circulated with the oil. When the water does mix intimately with the oil, a sticky emulsion results which is bound to interfere seriously with the proper functioning of valves and other structures.

Third, a good hydraulic oil should have a maximum of film strength.

This film strength is necessary to resist the severe wiping action that occurs between some of the moving parts in a hydraulic system; since a lubricating oil film under these conditions is only microscopic in thickness, it must possess *unusual* film strength.

Lack of lubricity results in unnecessary wear and excessive power consumption. Wear inside a machine increases internal clearances, thereby causing internal leakages, while wear at glands and stuffing boxes increases external leakage. Both reduce the overall efficiency of the machine.

Fourth, a good hydraulic oil should have proper viscosity and at the same time a minimum change of viscosity.

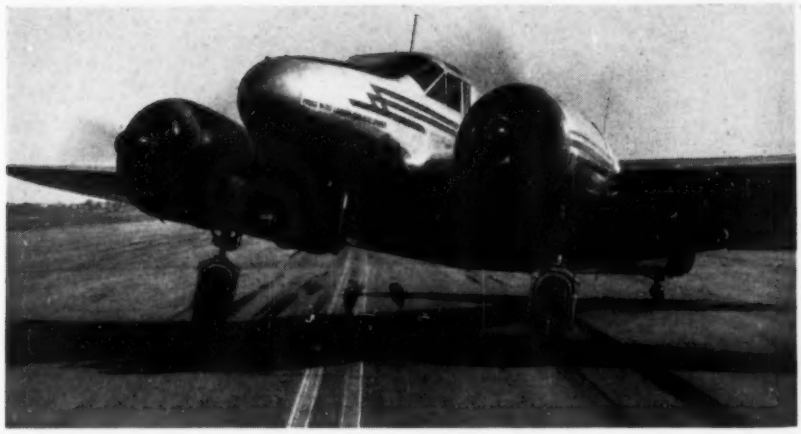
To minimize slippage (internal leakage) and to maintain maximum pump capacity in a hydraulic system and still be able to operate with a minimum of power consumption and at low oil temperature, it is extremely important to use an oil of the proper viscosity.

Since the design of the pump and the nature of the system determine the choice of viscosity of the oil to be used, it is the part of wisdom to follow the recommendations of the manufacturer of your particular system. He is certain to specify the most suitable oil viscosity for you to use. And you may depend on his judgment—it has cost him plenty of money to be able to make those recommendations.

In concluding this article, therefore, we would emphasize these two points as being of major importance. (1) The maintenance man who thoroughly masters the fundamentals of hydraulic operation will find his work not only easy but enjoyable. (2) The best hydraulic oil obtainable is in the long run the least expensive oil to use because it holds "down time" on a machine to a very low minimum.

SAVE THIS VALUABLE REFERENCE MATERIAL: BUILD UP A PERMANENT FILE

SWIVEL-HIP FLYING



A CASTERING landing gear, with a hydraulically loaded cam and vane type "shimmy" dampener built within a standard air-oil shock strut, has been developed for use on twin-engine airplanes. This gear permits safe cross-wind landings and take offs from single-runway air fields where previously large expensive multi-runway facilities were required.

All American Aviation, Inc., Wilmington, Del., under the auspices of the Civil Aeronautics Administration, designed and built this gear for use on retractable landing gear type airplanes. Previous work had been done on single-engine airplanes with stationary or fixed undercarriage.

Fixed gear proved no special design problem but the retraction required on multi-engine airplanes presented new difficulties. It was necessary to provide directional stability, "shimmy" resistance and a retraction motion that required no modifications of standard airframes.

The landing gear developed is essentially a modified standard air-oil shock strut, with a built in hydraulically loaded cam and "shimmy" dampener, that provides free castering of the main wheels about the strut axis. The hydraulic loaded cam produces a restoring torque that returns the wheel to a straight-ahead position and the vane type dampeners prevent wheel flutter and shimmy. The dampener is contained in the shock strut and uses the tube as its outer cover. The piston-action of the shock strut serves as the fluid and pressure source.

Restoring torque that returns the wheels to their straight-ahead position is obtained from a combination of the cam and vane actions. The vanes form chambers, with one side movable and the other stationary, that decrease in volume with any increase in angular wheel movement. This action increases the pressure in the chambers and increases the restoring torque. Oil is forced through adjustable openings in these chambers up into the top of the main shock strut cylinder. This forces the shimmy mechanism against the cam. Since the lowest point on this cam is the straight-ahead position, any change in direction will increase the restoring torque on the wheel.

This restoring torque keeps the wheels on a steady path when the airplane is on the ground and restores the wheel to straight-ahead position in the air, permitting unhindered retraction of the gear.

Because of this free castering effect, dampened and steadied by a hydraulically loaded cam and vane arrangement, it is possible for airplanes to take-off and land from single-runway airfields under a variety of wind conditions. This eliminates the need for cost and space restricted multi-runway facilities and opens the way for air transportation service to areas now without service.

LETTERS TO THE EDITOR

(Continued from page 24)

Answer:

We assume you mean by hydraulics the oil pressure systems for the operation and control of industrial equipment. Because of the newness of hydraulics as a separate branch of engineering, most existing texts are highly specialized phases of the subject or chiefly theoretical treatments. There are few good practical manuals. A list is being sent to you.

Answer to "F.D.E." (July issue)

The all-hydraulic automobile is in a class with Gelett Burgess' famous purple cow. The editor asks one question about ignition. Must we resort to the aviation practice of a portable power unit? And what would be the size of the generator required for lighting, operating a radio, a heater and the host of gadgets that seem to be coming in? If motor car manufacturers have an all-hydraulic model up their sleeves, they are pretty quiet about it.

J. T.

EDITOR'S NOTE: I wouldn't be too sure about classifying a possible all-hydraulic automobile with Mr. Burgess' famous cow. According to the July issue of READER'S DIGEST ("The Zaniest Man I Know", condensed from "Advertising & Selling"), Mr. Burgess has seen at least one purple cow. Seriously, the number of hydraulic elements on the modern automobile is still increasing and all of them are not gadgets either.

Answer to "A.W.L." (July issue)

We know of no good engineering text covering the design and installation of hydraulic systems. In addition to the installation and service literature of manufacturers of hydraulic structures and elements, some of the leading makers of tubing and fittings have good, practical manuals and bulletins that would be helpful.

This column is open to comments on general trade and technical problems. Comments are invited from our readers on questions or answers as published—EDITOR.

Applied HYDRAULICS DIGEST

Abstracts, summaries and listing of articles on hydraulic and associated applications in industry; reports on prepared papers, talks and discussions of special interest to the hydraulics field.

From Hydraulics to Fluid Mechanics

W. M. Lansford, *Journal of Engineering Education,* April 1948, pp 565-567.

An orientation picture of the place of modern fluid mechanics in the overall and much older hydraulic field. Principles are stated in their application to the analyses of practical problems. The fields in which fluid mechanics have important applications are listed.

Introduction to the Elementary Theory of Linear Servomechanisms

L. J. Laslett, *American Journal of Physics,* May 1948, p 260.

A simple development of linear servomechanisms, with particular attention to the stability problem is given. The connection between the methods of determining stability from the governing differential equation, the use of Nyquist's criterion and a study of the amplitude-frequency graph of the mechanism is indicated. The accuracy of following is treated briefly and an analysis is made of the speed-control servo. The importance of the treatment is in the fact that it is directed to the college student as an introduction to the theory of servo analysis. It is also a good orientation point for the engineer who wants to keep his feet on the ground and whose knowledge of servos is hazy or scant.

Hydraulic Remote Control

R. Westbury, *Aeroplane,* May 1948, pp 531-533.

A description of the "Remoter" system of remote hydraulic control, designed to eliminate or reduce the additional valve installation problems of the airplane designer, particularly that of the pressure of a mechanical linkage from the cockpit to the actuator. It is very important that the movement of the actuator be slowed down to eliminate large pitching moments. Essentially the unit is a hydraulic coupling from the cockpit to the actuator. It is a transmitter unit and consists of a variable pressure reducing valve and a receiver unit linked to the transmitter by a tube. The receiver is responsive to changes in pressure in the tube and controls the position of the actuator by pressure from the transmitter. The "Remoter" system has been installed in the AW-52 twin-jet tailless research plane built by Armstrong Whitworth.

Strainers Protect Costly Hydraulic Systems

John H. Schmid, *The Iron Age,* v 162, July 8, 1948, p. 89.

The installation of duplex strainers in the suction lines of pumps in a water operated hydraulic system, involving a forging and descaling operation in a stamping plant and press shop in Toledo, corrected a chronic clogging trouble that, before it was corrected, caused five shutdowns and cost in the neighborhood of $44,000.

The main hydraulic pumps, totally enclosed vertical triplex power pumps, had caused some trouble due to accelerated valve wear. A descaling system was installed but the descaling nozzles clogged up and failed to operate after a few hours. Examination disclosed that the foreign matter was chiefly dirt from the forging operation and packing lint. When the real trouble was run down the strainers were installed. These strainers are integral two valve units and provided continuous operation since one valve could be shut down and cleaned while the other remained in operation. The practical remedy, according to Mr. Schmid, is to protect pumping units, positive displacement meters, heat exchangers, solenoid and pressure controlling valves by the installation of properly designed strainers with the proper pressure, temperature, capacity, perforation basket, metals and other parts and requirements to do an adequate job of straining entrainment from pipelines.

The Kind of Remote Control Used Depends Upon the Distance

Lev A. Trofimov, *Electrical Manufacturing,* v 42, July 1948, pp 110-114.

The author states his problem as a three dimensional space problem with one of the dimensions exaggerated. The nature of remote control apparatus is dependent upon the distance or degree of remoteness. For applications where the distance is only a few feet, flexible cables, gears, chains, belts and extended solid shafts are considered in turn. The space problem and the multiplication of controlling power gives the designer an opportunity to consider hydraulic power and controls. For greater distances, the author believes electrical means are more commonly preferred, although he carefully gives

each power type consideration. He defines synchros as "simply electric shafting" and the distance along which rotation can be efficiently transmitted is limited only by the resistance of the secondary circuit. However, if a synchro is used to operate a speed-changing mechanism or a rheostat, the distance will be much shortened and depend on the secondary voltage drop which is a function of the distance and of the torque transmitted.

To transmit a linear or rotary motion accurately and to multiply the power of the operator, electric actuators (remotely controlled, geared motors with safety and limiting devices) are recommended. The author's choice for distance plus power-multiplication is the push-button controlled, reversible motor. Other electrical devices described and catalogued for their possible use are servomechanisms, bridge balanced circuits, bridge circuits with magnetic relays and electronic tubes. The material is more from the electrical than from a hydraulic point of view but many possible applications for hydraulic power and control units can be visualized by the careful cataloging and well chosen illustrations, including good equipment and circuit diagrams, used.

The "AN" Nomenclature System—How It Works

Charles De Vore, *Electrical Manufacturing*, v 41, June 1948, pp 122, 124, 126, 188, 190.

Mr. De Vore, a member of the Signal Corps Publications Agency, describes what the terms of "probably the only standardized equipment nomenclature system in the world in actual use today" mean and the plan of building identification means. The system is logical, comprising both a name and a type number and is flexible enough to lend itself to new types and applications of equipment. Adopted in 1943, after being worked out by the Joint Army-Navy Nomenclature Committee, the system is a single standard plan of nomenclature for communication and associated equipment. The same plan operates in the case of hydraulic equipment, components and structures.

The basic designation is a name followed by a type number. Standard engineering terminology was used in choosing names. The type number consists of appropriate indicator letters followed by a number. For a complete radar set, for example, the type number consists of the AN-system indicator "AN", followed by a solidus or slant bar and a basic indicator. The first letter indicates the type of installation, the second letter the type of equipment and the third letter the general military purpose for which the set is used. Adding a number to the basic letter indicates a specific complete set. For example, radar set AN/MPG-1 designates a standard Army radar set in current use. The "M" indicates the set is ground-mobile; the "P" that it is radar;

RACINE *Hydraulics*

HELP PRODUCE A CRANKSHAFT A MINUTE

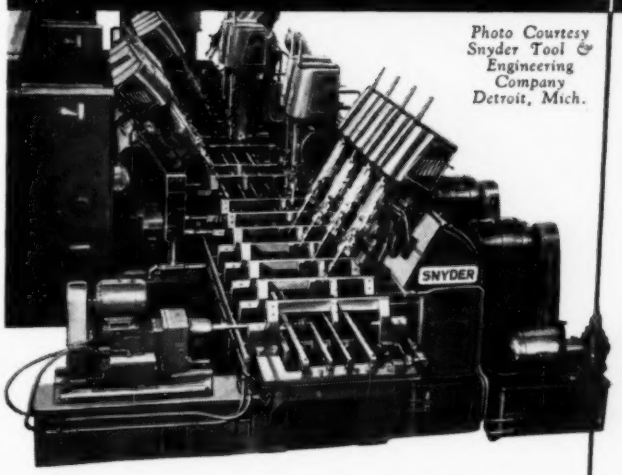
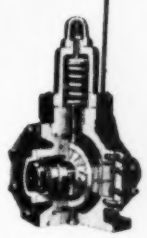


Photo Courtesy Snyder Tool & Engineering Company Detroit, Mich.

... in a modern *High Speed* automatic drilling machine



Four RACINE Variable Volume Pumps, each impelling six drilling units, supply the hydraulic power for drilling and reaming sixty crankshafts an hour on this Snyder "IN-LINE" special automatic machine.

Mounted on a single base and controlled at a central push button station, the machine shuttles each crank through twenty-eight stations. The complete work cycle of positioning, clamping, drilling and reaming is accomplished through hydraulically actuated vises and spindles in a smooth, rapid sequence.

Here, hydraulic automatic operation is protective as well as productive. When drills are overloaded because of excessive chip accumulation or variations in metal hardness, the spindles retract automatically, thus reducing drill breakage.

With RACINE constant pressure variable volume pumps, no accumulators, unloading valves or pressure reducing valves are needed to level out pressure fluctuations. Adjustments are thereby reduced from eight to one. There is less initial cost, lower operating expense and less possibility of breakdown.

This is but one example of the efficiency of RACINE hydraulics. It will pay you to investigate its possibilities for your work movement and handling problems. Let our hydraulic engineers work with you . . . no obligation. Address Racine Tool & Machine Company, 1774 State Street, Racine, Wisconsin. Ask for Catalog P-10-C.

RACINE *Oil Hydraulic* VARIABLE VOLUME PUMPS and *Hydraulic* VALVES — Pumps in capacities to 30 g.p.m. up to 3000 p.s.i. Four-way hydraulic valves, balanced piston-sleeve type, available in a wide range of styles and portings in ⅜" to 1½" i.p.s.

RACINE

STANDARD FOR QUALITY AND PRECISION

and the "G" that its normal military application is for gun direction or laying. The terminal "1" indicates that it is the first set of its type to which AN nomenclature was assigned.

The type number for a major companent of a set consists of one or two letters—called a component indicator—and a number, followed by a slant bar and a basic indicator. The same general plan of identification as for complete sets is followed. When component units are employed in a later or different use, the type number is not changed. AN nomenclature is not assigned to commercially catalogued articles, unless the assignment will aid military identification. Small parts are not identified by the system. The AN system is still fluid, changes, particularly in the direction of simpler, better methods, are still being made.

Air-Tracer Scans Contours in Machining Operation

Anonymous, *Compressed Air Magazine,* v. 53, July 1948, pp 171-172.

A description of the operation of the Air-Tracer, developed by The Bailey Meter Company, and now made and applied to their machines by The Monarch Machine Tool Company, under a license. The Air-Tracer is essentially a spring-loaded tracer that follows the contour of a pattern to be duplicated and at the same time guides the cutting tool of the machine by means of an air-hydraulic circuit. The scanner works on the air-gauging principle; compressed air at constant pressure is supplied to the system through an orifice designed to hold a given pressure when the circuit is in balance. The air loading pressure established by the tracer controls the movement of two hydraulic relay valves, one controlling the cross feed and cross traverse, the other longitudinal feed and traverse. The valves are actuated through flexible metal bellows; the valve stems are attached to the free ends of the bellows, so that movement of the relay valves is determined by the air-loading pressure.

When the tracer is scanning a straight section of the template, the air-loading pressure is balanced. The slightest change in template shape increases or decreases the air-loading pressure by changing the rate of flow from the air tracer valve. The deviation of the tracer from its balanced position is amplified into hydraulic relay valve motion in the ratio of 1 to 100. A diagram of the combined air-hydraulic circuit and illustrations of two types of work done are shown.

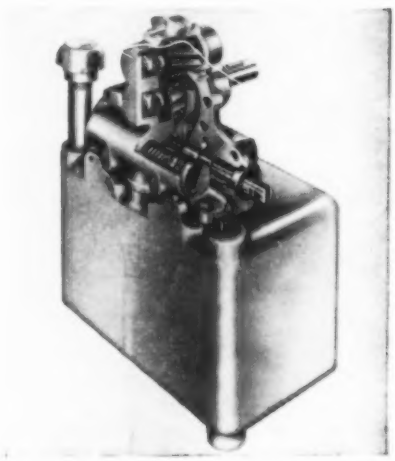
Reversing Hydromatic Propeller

Carl F. Baker, *SAE Journal,* v 56, June 1948, pp 21-23.

This article is a digest of the paper *"The Reversing Hydromatic and Its Control"*, presented at SAE Annual Meeting, Detroit, Jan. 15, 1948. This paper describes the hub mechanism and control system of the Hamilton Standard Hydromatic propeller modified for a new reverse switch model which produces negative thrust at negative blade angles for landing braking. Three major changes were made: the single-acting hydraulic system was replaced by a positive double-acting system; the cam slot in the hub mechanism (also used for changing pitch and feathering) was extended at a steeper angle at the end opposite the feathering range; and a new intermediate low-pitch stop was added. The hydraulic system used for feathering was adapted for reversing under separate actuation.

The modified system works as follows: when an increase in blade pitch is required to maintain constant speed, oil pressure exerted against a piston moves the piston and attached cam rollers in the axial direction. Axial motion is transformed into rotary motion of the blades by the cam rollers acting in helical cam slots. For decreasing pitch, new passageways were added to carry oil to the other side of the propeller piston. Double passageways for oil were already available in engines. Connecting passages were added in the propeller hub. Double passages made it easy to modify the hub mechanism for positive fast blade angle reversing to the negative position. All that was needed was an extension of the cam slot at the low-pitch range. The slope of the extension was made steep so that the blades

You Gotta See It To Believe It!



5 TO 20 G. P. M. TO 1200 P. S. I.

The design features Torrington needle bearings, hardened steel valves and shafts shock valve, bypass valve and tank capacity up to 3 gallons.

PUMP — VALVE & TANK $40.00
(500 quantities, slightly higher for small quantities)

WRITE FOR COMPLETE INFORMATION

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would turn rapidly. The existing mechanical low-pitch stop was converted into a fixed negative blade angle stop by setting the stop for the desired negative angle. An intermediate low-pitch stop was added. This acts as a positive stop except when reversing is demanded. The direction of blade motion is the same for reversing and unfeathering, for unreversing and feathering. On the new reversible-pitch propeller feathering is actuated by a pushbutton in the cockpit but reversing is actuated by the throttle.

When the throttle enters the reverse sector of the quadrant, it trips a switch which energizes a solenoid operated valve in the constant speed control and an electrically driven pump which supplies auxiliary oil for reversing and feathering. This valve allows the auxiliary oil to act against the pilot valve, moving it to a position where it directs both auxiliary oil and constant-speed-control oil through passages to act on the propeller piston in the decrease-pitch direction. For unreversing, the throttle is moved forward toward the neutral position. Throttle-actuated switches deenergize the solenoid valve in the constant speed ocntrol, then energize the electrically driven pumps for auxiliary oil. Pumping continues until the propeller piston has moved the blades to a point just beyond the low-pitch stops.

New Hydraulic Fluids Won't Burn

Anonymous, *Machine Design,* vol 20, July 1948, p 113.

New hydraulic fluids that will not burn and that are of a water-base composition are being developed for military and civilian use. The Naval Research Laboratory, Washington, D.C. has developed these hydrolube fluids to eliminate the fire hazard resulting from the use of petroleum-base fluids in hydraulic systems, particularly in aircraft.

The fluids have stood up under severe tests in Navy planes for two years and are approved for use in most Navy planes for the future. They are currently being tested for civilian use by the Civil Aeronautics Administration.

The first fluid of this type developed would not burn, had a freezing point of -50 F, was less corrosive than water, provided less packing deterioration and leakage, had good lubricating properties and all ingredients were available in America. Although the fluids have been tested without failures, experimental work is still progressing on their improvement.

Mr. Edward J. DeWitt, President of Wallace Tube Company, Chicago, states that reprints of his two articles "What the User Should Know About Tubing" which we digested in the May (page 26) and June (page 30) issues are available on request. The request states that they will be available to anyone who writes in on their business letterhead.

DENISON

High Pressure HydrOILic PUMPS

in both fixed and variable stroke types

A NEW simplified design eliminating bulk, features the Denison High Pressure HydrOILic pumps—resulting in a more compact and rugged unit. These pumps are so efficiently designed, they are virtually *one solid piece of metal,* and require but a minimum of space for installation. They are efficient and quiet in operation, even at highest pressures.

Constant displacement models are available in three sizes: 6, 17 and 32 gpm, for pressure to 5000 psi. Choice of face, flange or foot mounting types. Variable displacement models can be furnished in three sizes: 6, 17 and 32 gpm, with three types of displacement controls: handwheel, pressure compensating and pressure centering. Foot, face or flange type mountings are available. Write for details.

The DENISON Engineering Co.
1166 Dublin Road, Columbus 16, Ohio

DENISON EQUIPMENT for APPLIED HydrOILics

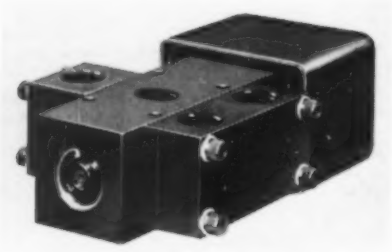
VALVES • FLUID MOTORS • PUMPING UNITS • HydrOILic PRESSES

New PRODUCTS

For additional information on any of these products, mark the end key numbers on the card bound in this issue and mail the card.

Solenoid Selector Valve

Saval, Inc. announces production of a new line of ac solenoid operated 4-way selector valves. They are designed for water, oil or air service at pressures to 250 psi. Sizes ranging from ¼ to 1 in are offered. The "Shear-Seal" principle, incorporating metal-



to-metal contact of sealing members, is used. Simplicity, direct operation and fast positive action are features of this valve design. Use Business Reply Card, mark NP-1.

Multi-Pole Relays

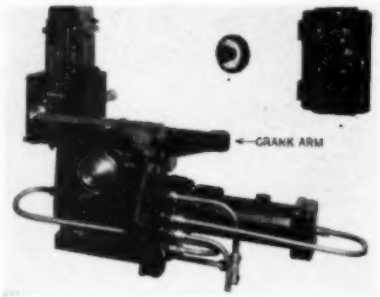
Multi-pole relays for machine tool control are available from Square D Company. Two models, Type Q with 2 to 6 poles and a larger and heavier Type R with 2 to 5 poles, are offered in any combination of normally open and normally closed circuits. They are readily converted from normally open to normally closed. The double-break, silver-to-silver contacts of these dc relays are interchangeable with those of corresponding ac devices made by the same manufacturer. Both relays can operate on dc voltages to 250. Use Business Reply Card, mark NP-2.

Hydraulic System Solvent

A new sludge and gum solvent has been developed by the Swan-Finch Oil Corporation. The new product, known as Hydro-Solv "A", can be added to regular hydraulic oils to remedy sluggish operation caused by contaminants. After 100 to 150 working hours the solution and oil are removed and the hydraulic oil is replaced. The solvent is not a lubricant in itself but it is non-corrosive and will not affect fine surface finishes. Use Business Reply Card, mark NP-3.

Cylinder Remote Control

The electronic remote control unit just announced by Askania Regulator Company can position hydraulic cylinders with accuracy of movement to 0.1 percent. The remote control station can be placed as far as 1000 feet away. Consisting of a remote transmitter, transmitter



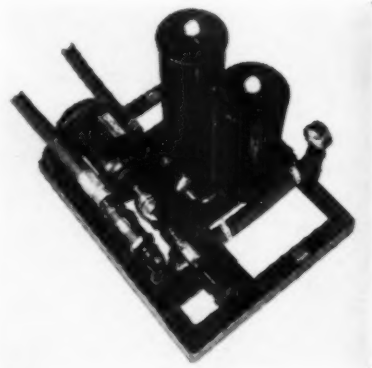
and receiver, hydraulic crank type cylinder and a receiver mounted on the cylinder, this system translates a small electric signal into a position movement of the cylinder. The hydraulic force resulting can be made to move heavy valves, dampers or other control mechanisms. Use Business Reply Card, mark NP-4.

New Solenoid

The Soreng Mfg. Corp. is producing a T-type design solenoid for pull application on 110 volt ac. This new solenoid is available in two sizes with stroke at ⅝ and 1 in. The 1 in unit exerts 4 lb pull at full stroke, 12 lb at ⅛ in from closed. A mounting base is included with each unit. Use Business Reply Card, mark NP-5.

Hydraulic Filters

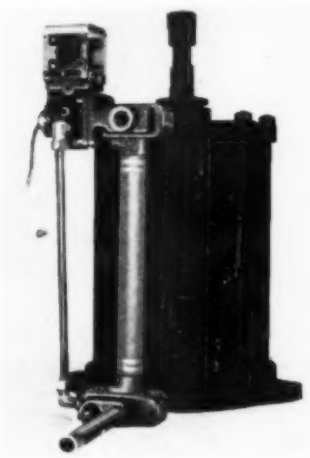
General Filters, Inc. has available three oil filters recommended specifically for hydraulic service. Model AF-2000, shown in cut, is a portable unit consisting of two filters, pump and motor mounted on a base.



The two filters double filtering area and increase rate of flow. The filter elements, removable for cleaning, can remove solids down to 5 microns in size. Two other complete units are available; one unit with a 15 psi by-pass valve and the other without. Use Business Reply Card, mark NP-6.

Air Cylinder Control

A new type of air cylinder

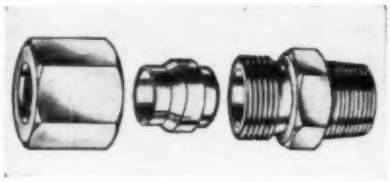


control has been developed by Numatics. This system consists of an individual control unit, attached directly to the air cylin-

der head, that is basically a full capacity 3-way valve placed directly in the line. Any type of control is possible, either at the cylinder or at a remote distance. These units are available in ½, ¾ and 1 in pipe sizes. Use Business Reply Card, mark NP-7.

High Pressure Fittings

The Fluid Fortress tube fittings manufactured by Flodar Corporation, are designed to



withstand the shock and absorb the vibration of high pressure hydraulic service. An alloy steel slotted-end grip sleeve is used to grip and support the sleeve by forcing it into the tube wall and locking it with a connector body and nut. A metal-to-metal seal is formed. Male and female fittings are made in sizes from ¼ to 1½ in for straight, tee and union types as well as 45 and 90 degree ells. Use Business Reply Card, mark NP-8.

High Pressure Coupling

The Bar-Way Manufacturing Company announces the production of a new high pressure hose coupling that will withstand pressures in excess of 3000 psi. It is available in ½, ¾ and 1 in sizes. Made of bronze, it is recommended for use only with rubber covered fabric hose. The full inside diameter of the hose is maintained throughout the coupling; therefore there is no friction loss or restriction of flow. Use Business Reply Card, mark NP-9.

Pneumatic Timing Relays

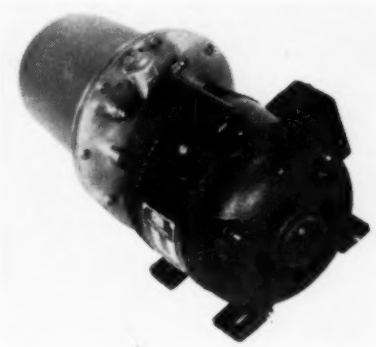
Cutler-Hammer Inc. announce the development of a new ac pneumatic timing relay recommended for use on machine tools and automatic processing equipment where dependable timing is required. Small size, flexibility of timing arrangements and ease of adjustment are characteristics of this relay design. The relay is available in open or enclosed versions, with timing in one or two steps and time delay before or after energizing of timer coil. The timing range is adjustable from 0.3 seconds to 3 minutes. Operating voltages range from 115 to 550 ac. Use Business Reply Card, mark NP-10.

Air Filter and Lubricator

A low-cost combination lubricator and filter for compressed air lines is offered by Jarett Compressor & Equipment, Inc. It cleans air automatically through a permanent type, cleanable filter element and injects the proper amount of atomized oil into the line automatically. The air flow is unrestricted through ¼ in pipe openings. Use Business Reply Card, mark NP-11.

Lightweight Hydraulic Unit

A new lightweight hydraulic unit is now available from John Dusenberry Company. Designed for control of hydraulic cylin-



ders or as a substitute for compressed air, this unit is available for capacities from 0.1 to 3.9 gpm at pressures from 100 to 1000 psi. It includes pump, 5-pint reservoir, electric motor and check and relief valves. The valves can be mounted internally or externally and the motor furnished open or totally enclosed, as required. They operate on standard voltages. Use Business Reply Card, mark NP-12.

Automatic Sealing Couplings

Automatic shut-off and instantaneous flow are the important features of a new series of couplings offered by Roylyn, Incorporated. This coupling, series 1300, is designed for operation over a wide pressure and temperature range. It is available with the valve in either or both halves of the coupling. Dural,

bronze and steel units are offered in sizes ranging from ¼ to 2 in. Use Business Reply Card, mark NP-13.

Pressure Switch

A pressure switch for air service up to 175 psi is produced by Workrite Products Co. Vertical or horizontal mountings are available with ¼ in pipe thread. The switch is a two pole unit, factory set at 110 lb on and 150 lb off, that will operate on dc, and single phase or polyphase ac current at voltages to 550. Use Business Reply Card, mark NP-14.

Midget Circuit Breaker

A shock resistant midget circuit breaker, capable of withstanding shocks as high as 500 ft-lbs, is offered by Westinghouse Electric Corporation. The use of a unique damping arrangement incorporating a cantilever bimetal overload element makes this possible. The overload element is shaped like a fish hook; temperature rises reduce the radius of the hook and deflect it away from the circuit. This combination produces an interrupting capacity of 5000 amperes at 125 volts ac. Use Business Reply Card, mark NP-15.

(Continued on page 35)

POST SCRIPTS OF INDUSTRY

NEWS · VIEWS · TRENDS

The fourth National Conference on Industrial Hydraulics sponsored by Armour Research Foundation and Graduate School of Illinois Institute of Technology will be held October 20 and 21 at Hotel Sheraton, Chicago. S. F. Musselman, conference secretary, states that the program is now practically complete and that advance abstracts of papers will be released shortly. It is expected that a well rounded program will be presented; and that it will be of even greater value to field men as well as engineers and executives than previous conferences.

Air-Mite is the new name for Air-Trol, Chicago manufacturer of industrial air equipment.

Micromatic Hone Corporation has purchased the drawings and patterns of the Ultra Lap Company and will manufacture a new line of flat surface finishing machines.

A new division of Borg-Warner Corp. has been formed by the consolidation of Morse Chain Co. and the Formsprag Co. It will be called the Morse-Formsprag Co. and will have sales offices at 7601 Central Ave., Detroit. This company has developed a completely new line of over-running clutches for industrial use.

Industrial Research Institute Inc. has recently elected new officers. E. W. Engstrom, vice president in charge of research, RCA Laboratories Division, Radio Corp. of America, has been elected president and J. H. Schaefer, vice president and general manager, Ethyl Corp., has been elected vice president. C. G. Worthington was re-appointed secretary and treasurer. At the same time C. F. Rassweiler, vice president in charge of research and development, Johns-Manville Corp. and Alex Stewart, director of research, National Lead Co., were elected to three-year terms on the board of directors.

Marvel Engineering Company, in their third expansion since organizing in 1943, have moved into larger quarters at 625 W. Jackson Blvd., Chicago.

Bundy Tubing Co., Detroit, announces the appointments of Austin-Hastings Co. Inc., Cambridge, Mass. as its distributor for New England and A. B. Murray Co. Inc., Elizabeth, N.J. as its agent south and west of New York City.

Carbide and Carbon Chemicals Corp. has opened a sales office at 44 Broad Street, N.W., Atlanta, Georgia. Ray G. Kelso has been appointed district manager for this area.

Independent Pneumatic Tool Co. has moved from Chicago to Aurora, Ill. A Chicago office for sales and service will be maintained at 600 W. Jackson Blvd., pending construction of a new branch office building.

Roots-Connersville Blower Corp., Connersville, Ind., has opened a district office at 2306 East 22nd Street, Cleveland, Ohio, with Franklin F. Bogardus as district sales manager. Roots-Connersville is affiliated with Dresser Industries, Inc.

Dayton Rogers Mfg. Co. has recently appointed Marvin C. Barnum as their New York representative.

Sperry Products, Inc., have announced a price reduction on their standard hydraulic controls according to J. W. Dice, product sales maanger. The Type F control has been reduced 10 percent; the Type H control 30 percent. In August, headquarters at Hoboken, N. J., are scheduled to move to Danbury, Conn.

Minneapolis-Honeywell Regulator Co., Minneapolis, has announced the following personnel changes: Kent L. Wilson has been promoted to manager of southwest region with headquarters in Dallas. He will be succeeded as Detroit manager by T. S. Carley; Walter J. Baak has been promoted to sales manager, Wholesale Division; and William S. Robards has been appointed Milwaukee branch manager to succeed the late L. C. Johnson.

Some time in August the United States automotive industry will produce its 100 millionth motor vehicle. Nobody will know who builds this vehicle but it will roll off the assembly line of one of the 113 car, truck and bus plants located in 77 cities of 24 states. The 100 millionth vehicle will mark 55 years of motor vehicle production with about 44 million still in operation.

Watson-Stillman Co., Roselle, N.J., recently celebrated its hundredth anniversary, according to an announcement by Edwin A. Stillman, president. From its founding in New York City to its present location in New Jersey, this company has had uninterrupted management under direct descendants of the founder. Two moves were made, in 1860 and 1886, within the city of New York; the third move, upon incorporation of the company in 1904, located the plant facilities in Roselle, N.J.

SALES REPRESENTATION OPPORTUNITY

Phillips-Drucker is looking for sales representatives for hydraulic pumps, valves, etc. (see ad this issue). Prefer hydraulic engineers with sales ability. Write immediately to 2245 S. Vandeventer Ave., St. Louis 10, Mo.

NEW PRODUCTS

(Continued from page 33)

Steel Check Valve

Stainless steel straight check valves of the cone type are produced by Kohler Co. Designed for service on hydraulic systems employing pressures up to 3000 psi, these valves are offered in four sizes ranging from ¼ to ⅝ in pipe. They are designated as K-1249 and are made in accordance with Army-Navy Specifications. Use Business Reply Card, mark NP-16.

Solenoid Valve

A self-closing, quick acting solenoid valve for operation on air, oil and water lines is offered by Hays Mfg. Co. These valves are designed for continuous and intermittent operation and are capable of remote control, automatic control and time cycle operation. Flared copper tube, solder connection and female iron pipe piping methods are available. Use Business Reply Card, mark NP-17.

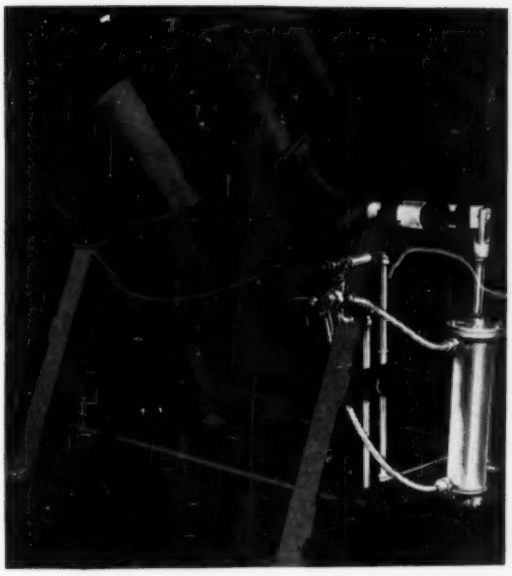
Relief Valve

Electrol Incorporated offers a relief valve with pressure range from 500 to 2100 psi and a very small range from cracking to full open to re-seating. Two ports, pressure and return, are in the same plane and are 3-8/18 in pipe size. Another model with ¾ in ports and with the same pressure range is also available. These units are small and lightweight and have a rate of flow up to 6 gpm. Use Business Reply Card, mark NP-18.

Flow Indicator

The Stroboflow meter, a flow indicator that permits adjustments of liquid flow rates to tolerances of one twentieth of one percent is being manufactured by Flowmeter Corporation of America. A precision-made turbine, mounted on pivots, is allowed to rotate with the liquid flow; the rotational speed of this turbine is used as a measure of the fluid flow. Use Business Reply Card, mark NP-19.

TILTING SAFELY



IT IS no longer necessary to have strong men handle large pouring and agitating kettles; a woman or girl can now operate the heaviest piece of this type equipment with perfect safety, thanks to hydraulic power. A hydraulic cylinder replacing the standard worm gear tilting mechanism previously used on trunnion kettles makes this possible.

This hydraulic cylinder tilting assembly, [developed by Lee Metal Products Company, Inc., Philipsburg, Penna.,] operates on city water pressure and incorporates a four-way control valve that regulates pressures on both sides of the cylinder plunger. With this arrangement the tilting kettle can be stopped at any point in its travel or reversed if desired. The action of this cylinder is so smooth and positive that a tea cup can be filled from a 300 gallon kettle without overflowing.

The tilting assembly consists of a hinged bracket attached to the bottom of the hydraulic cylinder and to the frame of the kettle. In place of the previously used worm gears, a steel arm keyed to the trunnion shaft and attached to the cylinder rod end, is incorporated. To control or limit the tilting action the stroke of the plunger is adjusted to the down position when the kettle is in upright position, and at its maximum height when the kettle is a little beyond complete pouring position.

The control valve is mounted on the front leg of the kettle stand frame for convenience of the operator and is connected to the city water line and to the drain by heavy rubber hydraulic tubing. A check valve, kept closed when kettle is not in use, is located just above the control valve on the frame.

To dump the kettle operator opens the control valve, allowing water from the main to enter the lower end of the cylinder; at the same time forcing the water from the upper end to discharge into the drain. When the kettle has been emptied it can be kept in the tipped position for cleaning or it can be returned to the upright by reversing the valve. The reverse motion is smooth and positive because of the cushioning effect of water in the lower part of the cylinder. No latch or locking mechanism is required to keep the kettle in upright position, for it cannot possibly tip until the valve is again reversed for dumping.

The use of hydraulic tilting actuation to replace the older standard arrangement has made possible the operation of larger size kettles and agitators with smoother, faster kettle and agitator movement. This spells increased safety for the operator and greater profit for the producer.

Useful Literature

The publications listed are available without charge. Mark the initial key number on the card bound in this issue and mail.

25. Hose Fittings . . . Catalog Section 3100, prepared by The B. F. Goodrich Company, describes the fittings offered for use with the hose produced by this company. Shank type couplings, high pressure couplings, clamps and nipples are included. Each fitting is illustrated and described and sizes are listed. Also included is a section on recommendations for selecting and attaching couplings.

26. Control Valves . . . Two catalog sections, Files VIA and V1B, are available from Hydraulic Equipment Company. Control valves in two types of mountings are shown. They are available with from one to four plungers, type A mounting and with one to four plungers in type B mounting. Maximum operating pressures are 1000 psi and maximum capacity 14 gpm. Design and cross-sectional drawings showing constructional details and photographs showing mounting types are included.

27. Solenoids . . . The National Acme Company is distributing Bulletin No. EM-46 on their "Stellite" welded solenoids. For alternating current use only, these solenoids are offered in combinations of push and/or pull arrangements. They are rated at from 2½ to 25 lb and have a maximum travel of 1 in; although they are rated for constant duty the same units are available for intermittent duty. Illustrations of typical applications are shown and design drawings and series photographs are included.

28. Air Controls . . . Bendix-Westinghouse Automotive Brake Company review their industrial controls in a loose-leaf catalog; air chambers and valves are included. The air chambers have strokes ranging from 1¾ to 3 in and the control valves are fitted with ¼ and ⅜ in pipe thread connections. Air hose fittings are also shown. Drawings and photographs show design features and typical industrial applications.

29. Limit Switch Circular . . . A circular GEA-4644 outlining the features of limit switch CR-9440-K1 is obtainable from General Electric Company. Designed for machine tool and general industrial applications, the switch is of the snap action type with interchangeable heads and oilproof construction.

30. Steel and Monel Tubing . . . The double wall steel and monel tubing produced by Bundy Tubing Company are presented in a descriptive bulletin now available. Both compositions are available in sizes ranging from ⅛ to ⅝ in O.D. In addition to size and physical characteristics charts, methods of manufacture, properties, fabricating information and coatings are discussed and drawings and photographs included.

31. Air Cylinders . . . Bulletin AC-2 reviews the double acting air cylinders produced by Lindberg Engineering Company. The cylinders are offered in seven types of mountings with bores ranging from 2 to 7 in dia. Photographs, design drawings and dimensional charts for all cylinder types are included.

32. Hydraulic Hose Assemblies . . . C. A. Norgren Co. offers a line of high pressure hydraulic hose assemblies. The hose is compounded of synthetic rubber and is recommended for use at temperatures from minus 40 F to 250 F. Combinations of male and female ends are available in sizes ranging from ¼ to 1 in. Installation directions and dimensional charts are included.

33. Power Units . . . The "package" hydraulic power units, for machine tool operation, produced by Ex-Cell-O Corporation are described in Bulletin 45361. Three styles are available with drive horsepowers ranging from 1 to 10, with direct pump drive or individual drive through pulley and V-belt. Each unit is compact. The hydraulic system is completely enclosed within the housing and contains a variable volume pump, reservoir and control valves. Specifications and features of individual units are shown and some applications on typical special-purpose machines are included.

34. Oil Seal . . . Pamphlet PK 31A-8 describes the new type oil seal produced by Johns-Manville. These "Clipper Seals" are recommended for sealing against oil, water or air at operating temperatures up to 225 F. They are furnished with garter springs and are available in shaft sizes from ⅝ to 68 in. Illustrations and a dimensional chart and mould list are included.

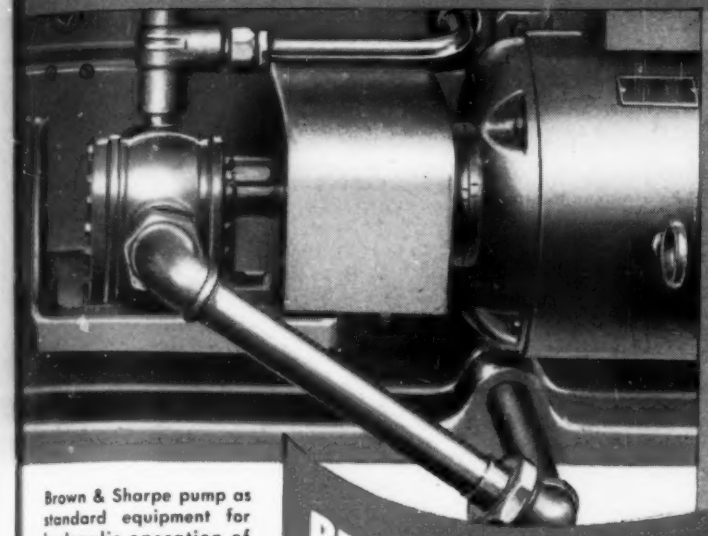
35. Industrial Controls . . . The photoelectric and electronic controls offered by Photoswitch, Incorporated are shown in Bulletin 504. Photoelectric controls, electronic timers, electronic pilot relays and registration controls are included. Photographs of each type are shown and the supplementary bulletins available are listed.

36. Filters and Mixers . . . Bulletin 144, published by the Alsop Engineering Corporation, illustrates their line of mixers and disc-type filters. Examples of many types of industrial filter applications are illustrated.

37. Air Cylinders . . . Miller Motor Company, in Bulletin A-105, describe the non-rotating air cylinders they produce. Bore

(Continued on page 38)

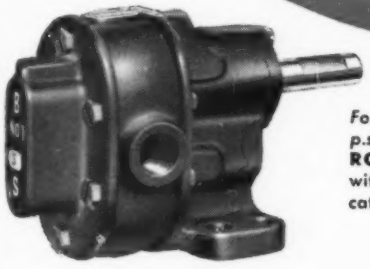
RIGHT in their element . . .
ON HYDRAULIC SYSTEMS



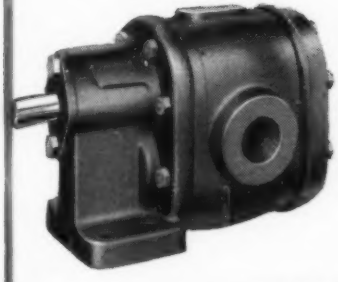
Brown & Sharpe pump as standard equipment for hydraulic operation of machine tool.

Compact installation of Brown & Sharpe pump for hydraulic operation of stoker unit.

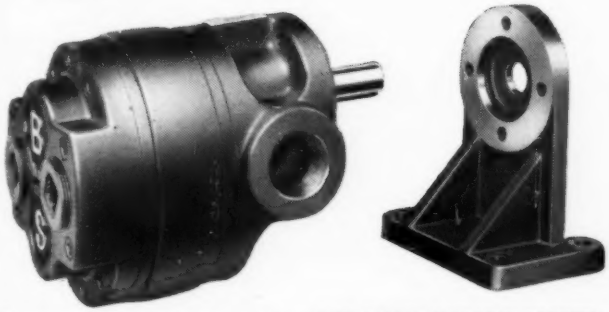
BROWN & SHARPE Rotary Geared PUMPS



For pressures up to 100 lbs. p.s.i. . . . **NOS. 1S, 2S and 3S ROTARY GEARED PUMPS** with helical gears. Self-lubricating.



For pressures up to 200 lbs. p.s.i. . . . **NOS. 53 and 55 ROTARY GEARED PUMPS** with roller bearings and helical gears.



For pressures up to 500 lbs. p.s.i. . . . **500 SERIES ROTARY GEARED PUMPS**—six sizes—with Herringbone Gears. Needle bearings, ground joints, alloy steel shafts, reversible back drain for reversing rotation. All moving parts balanced hydraulically . . . the 4 larger sizes, are balanced mechanically also. Foot-type mounting brackets available to meet practically any mounting condition.

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USEFUL LITERATURE

(Continued from page 36)

sizes range from 1½ to 14 in in a variety of mountings. Double or single acting cylinders are available in cushioned or non-cushioned arrangements. Operating pressures are up to 200 psi. Design drawings and dimensional charts are included.

38. Industrial Air Equipment ... The cylinders, regulators, valves and fittings produced by Air-Mite are reviewed in Catalog No. 47 A. Cylinders, in four different mounted models, are offered in bore sizes ranging from 1½ to 5 in with strokes from 1½ to 3 in. They are of the spring return type. Quick exhaust valves, exhaust silencers, speed control valves, coupler units and foot operated valves are also shown.

39. Hose Assembly . . . The Hydra-Flex wire-braided hose assemblies produced by Atlantic Metal Hose Co., Inc., are described in Bulletin 60. They are furnished as complete assemblies only in sizes ranging from ¼ to 1½ in for pressures to 5000 psi. Lengths are up to 50 ft. Illustrations showing construction and assembly setup are shown.

40. Air Control Valves ... Catalogue No. 48 describes the air control valves produced by Airmatic Valve, Inc. Flow control, quick exhaust and sequence valves are available in 6 standard pipe sizes from ¼ to 1¼ in. Three- and four-way hand and foot controlled, three-way cam controlled, two-way vacuum and three-way solenoid controlled valves are also offered. Design drawings and photographs of each valve type are included.

41. Hydraulic Overload ... The hydraulic overload Pitman produced by Dayton Rogers Mfg. Company is described in bulletin F-85 as to application and operation. The overload Pitman is used primarily to eliminate press crank and frame damage due to overload. A calibrated hydraulic relief valve can be set for any desired working tonnage for protection of maximum press capacity or to protect any given set of tools or dies.

42. Velocity and Pressure Drop Calculator ... Tube Turns (Inc.) have prepared a velocity and pressure drop calculator in the form of a handy slide rule. Liquid flow and gaseous flow problems can be solved on this calculator. Quick estimates can be obtained using a pipe friction factor and accurate solutions can be derived by applying a correction factor. Both factors are incorporated in the calculator and directions for operation are included in a convenient folder.

43. Pneumatic Measuring Instruments... Data Book No 1000 issued by Republic Flowmeters Company presents the principles of industrial measuring instruments that incorporate pneumatic force-balance. Two introductory sections cover principles of measurements and the principles of pneumatic force-balance; performance and construction features involved are mentioned. Differential pressure transmitters, pressure transmitters, liquid density transmitters and liquid level transmitters are reviewed in detail.

44. Air Cylinders and Valves ... Hannifin Corporation review their line of pneumatic cylinders and valves in Bulletin No. 57-B. Series "R" cylinders are offered in 3 to 12 in bore and series "LW" in 3 to 12 in bore. Adjustable cushion is optional. Air control valves and pressure regulators incorporate disc type design; they are available in a full range of types and sizes for air service to 150 psi and hydraulic service to 250 psi.

45. Check Valves . . . Bulletin No. 1001 describes the Series 1000 check valves produced by Pokorney Manufacturing Company. Recommended for air compressor and water applications to 150 psi, these piston operated check valves are available in five size ranging from ⅛ to ¾ in pipe. A dimensional chart and a cutaway drawing are included.

BOOK REVIEWS

Centrifugal and Axial Flow Pumps

A. J. Stepanoff. *Development Engineer, Ingersoll-Rand Company. 428 pages, 5¾ x 9 inches. Published by John Wiley & Sons, Inc., at $7.50.*

This book is an exhaustive and practical presentation of the theory, design and application of centrifugal, mixed flow and axial flow pumps. Included is a new and simple treatment of the impeller which applies equally well to centrifugal and axial flow pumps. Numerous examples of modern pump designs and installations are given.

The theoretical treatment of the centrifugal pump impeller deviates from the methods used in most existing texts on the subject. This new approach is based on: a single pattern of flow; identical theoretical thinking; and similar procedure of impeller layout for centrifugal mixed flow and axial flow pumps. As a result a simple diagram has evolved combining the important design elements and performance characteristic of all centrifugal pumps and is in a sense a "Mollier diagram" of both centrifugal and axial pumps.

The introductory chapters are of a basic nature and serve to refresh the memory of the readers on the equations, theories and definitions encountered in this book.

Three chapters — Design of Mixed Flow Impellers for Centrifugal Pumps, Cavitation in Centrifugal Pumps and Special Operating Conditions of Centrifugal Pumps — are evolved from articles that have received first prize awards from the Hydraulic Institute.

This book is for the practicing design engineer concerned with the theory, design and application of centrifugal, mixed flow and axial flow pumps. Design drawings, performance curves and charts and complete pump characteristics diagrams are used throughout.

PERSONALS

MALVERN J. HILER has been appointed vice president of The Commonwealth Engineering Company, Dayton, Ohio. He will be in charge of customer relations.

TOMMY J. Mc CUISTION has been appointed Ohio field representative for Plastic and Rubber Products, Inc. of Dayton, Ohio. Mr. McCuistion comes to this company from Battelle Memorial Institute, Columbus, Ohio, where he directed fundamental research in "O" ring packing problems under a joint Army-Navy project. He is also the author of many outstanding technical papers presented before the Society of Automotive Engineers and American Society of Mechanical Engineers.

Mr. McCuistion

J. R. POWELL has been appointed branch manager of the newly opened Bailey Meter Co. branch in Charlotte, N. C.

HEYLIGER CHURCH, vice president in charge of sales of The Weatherhead Company, Cleveland, has been named executive head of all sales divisions, domestic and foreign. R. P. Gibson, formerly vice president in charge of the automotive sales division and manager of the Detroit office, has been appointed vice president and general manager with headquarters in Cleveland.

ALVIN B. COPELAND has been appointed eastern sales manager for Gits Brothers Mfg. Co. of Chicago. He was formerly project engineer for Bendix Products Div., South Bend, Ind.

RUDOLPH E. KRUEGER, formerly chief engineer for the Accessories Mfg. and Engineering Co., has been appointed chief designer of pressurized equipment for the Pacific Airmotive Corp., Burbank, Calif. The former company has recently been acquired by the latter.

LLOYD L. LEE has joined the staff of Cleveland Republic Tool Corp. as manager of the Detroit office. He was formerly in charge of sales and engineering for Plan-O-Mill Corp., Hazel Park, Mich.

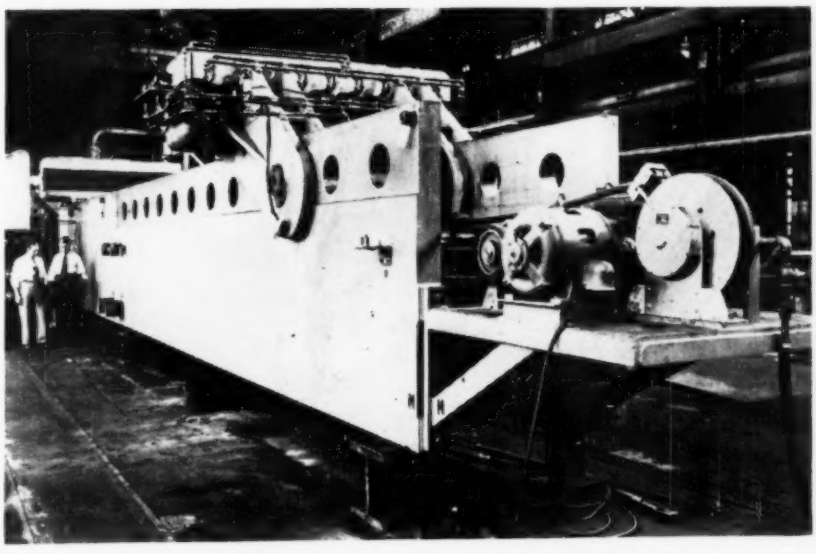
JOHN W. OVERBEKE has been appointed staff engineer for special projects of The Parker Appliance Company, Cleveland, it was announced by R. H. Davies, engineering manager of the company. He will direct development in special aircraft projects. Overbeke was staff engineer in charge of hydraulics for Glenn L. Martin in Baltimore from 1940 to 1942 and chief engineer for Simonds Aerocessories, Inc. of New York from 1942 to 1946. Prior to joining Parker he served as consulting engineer in New York and Cleveland.

Mr. Overbeke

DANFORTH K. HEIPLE, field engineer for LeTorneau Inc., Peoria, Ill., has been promoted to chief field engineer.

Safety in Industry

According to a report made by the National Safety Council, the accident record of American industry showed a definite improvement in 1947 over 1946. Reports from 40 divisions averaged a ten percent gain in safety. The average number of disabling injuries was 13.26 per million man hours. The lowest rate, achieved in the communications industry, was a rate of 2.98 and the manufacturers of electrical equipment were next with 6.02. The accident severity rate was reduced by 7 percent, the average 1947 figure being 1.23 days lost per thousand man hours.



HYDRAULIC PLATE STRETCHER-LEVELLER

A specially designed hydraulic stretcher-leveller, believed to be the largest ever made, was recently built by Hydropress, Inc. of New York. It is of the self-contained oil hydraulic type with one of two gripheads actuated by a hydraulic stretching cylinder. The position of the other is adjustable to plate length. This machine, shown in the illustration, has a capacity of 825 tons and can accommodate plates or sheets up to 100 in wide. It is operated by remote control from a central panel.

LA MOTTE T. COHU has been elected president and general manager of Consolidated Vultee Aircraft Corp., San Diego, Calif. He also becomes a member of the board of directors, succeeding V. C. Schorlemmer who has just resigned.

P. F. BAUER has been named manager of a newly formed central region of Allis-Chalmers general machinery division with headquarters in Cleveland, according to an announcement by J. L. Singleton, vice president and director of sales of the division. Bauer joined Allis-Chalmers in 1928 and served as a salesman in the Pittsburgh district office.

JOHN D. BALDWIN, JR., has been appointed chief product engineer and Charles H. Crawley has been named chief design engineer of the engineering department of The Weatherhead Company, Cleveland.

E. E. BAUER has been named manager of the central sales district of Peerless Pump Div., Food Machinery Corp., with headquarters in Chicago.

JAMES MATTERN has been appointed production planning manager of the Sperry Gyroscope Co., Division of the Sperry Corp., at Great Neck, N.Y.

FRANK R. KOHSTAMM has been elected vice president of Jack & Heintz Precision Industries Inc., Cleveland. He joined the company last October as general sales manager.

EDWARD M. BORGER has been elected a director of Dravo Corp., Pittsburgh. He fills a vacancy created by the retirement of S. G. Cooper.

E. F. RESCH succeeds W. D. Reed as vice president in charge of sales for Sawhill Mfg. Co. Mr. Resch has been associated with Mercer Tube & Mfg. Co. and was recently appointed Philadelphia district sales manager for both companies.

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